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The Engineer

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PUBLIC NOTICES

Civil Service Commission.

FORTHCOMING EXAMINATION.

ASSISTANT ENGINEER in the Engineer-in-Chief's Department of the General Post Office (20-25, with extension in certain cases), 2nd March.

The date specified is the latest at which applications can be received. They must be made on forms to be obtained, with particulars, from the SECRETARY, Civil Service Commission, Burlington-gardens, London, W. 1. 7253

INDIAN SERVICE OF ENGINEERS AND ENGINEERING ESTABLISHMENT OF INDIAN STATE RAILWAYS.

The Secretary of State for India in Council will in 1922 APPOINT 11 ASSISTANT EXECUTIVE ENGINEERS for these Services if so many suitable candidates present themselves.

Every candidate must be a British subject, or a ruler or subject of any State in India in respect of whom the Governor-General of India in Council has made a declaration that he is to be considered eligible.

The appointments for Europeans will be reserved for candidates who have served in His Majesty's Forces during the war for at least one year, or who have been permitted on adequate grounds from so serving. European candidates must have been born on or after 2nd August, 1896, and on or before 1st August, 1900.

Indian candidates must have attained the age of 21 and not attained the age of 24 years on 1st July, 1922, except that in the case of an Indian who has rendered service of the nature defined in the preceding paragraph, the same maximum age limit as for Europeans will apply. Subject to this exception, the maximum age limit of 24 years for Indian candidates will be maintained for the next year and will be reduced to 23 years in 1924.

Every candidate must either (1) have obtained one of certain recognised university degrees or other distinctions in engineering, or (2) have passed Sections A and B of the Associate Membership Examination of the Institution of Civil Engineers, or been exempted by the Institution from such examination, or (3) produce the required evidence that he is otherwise eligible under the Regulations.

Applications from candidates must reach the India Office not later than 1st April. Printed forms, together with information regarding the conditions of appointment, may now be obtained from the SECRETARY, Public Works Department, India Office, Whitehall, London, S.W. 1.

India Office, London,
12th December, 1921. 7419

City and Guilds (Engineering) COLLEGE.

CHAIR OF ELECTRICAL ENGINEERING.

The Delegacy of the City and Guilds (Engineering) College invite APPLICATIONS for the APPOINTMENT to the PROFESSORSHIP and HEAD of the DEPARTMENT of ELECTRICAL ENGINEERING in the College, in succession to Professor T. Mather, F.R.S., as from the commencement of the session 1923-3.

The College forms the Engineering Section of the Imperial College of Science and Technology and is conducted by a Delegacy representing the Imperial College, the City and Guilds of London Institute, and the Goldsmiths' Company.

A copy of the terms and conditions attached to the appointment may be had on application to the SECRETARY to the DELEGACY, City and Guilds (Engineering) College, Exhibition-road, London, S.W. 7373

The Polytechnic, 309, Regent-STREET, W. 1.

The Governors will shortly proceed to APPOINT a HEAD of the ENGINEERING SCHOOL (Day and Evening). Salary, according to Burnham scale for technical teachers, £700 to £900. Duties to commence September 1st.

Candidates should have good academic qualifications, practical and teaching experience.—Application (on special form) must be made on or before 6th March, 1922, to the DIRECTOR OF EDUCATION, from whom further particulars may be obtained. 7422

Royal Show.

CAMBRIDGE.

JULY 4TH TO JULY 8TH, 1922.

EXHIBITION OF IMPLEMENTS, &c.

The REGULATIONS and FORMS of APPLICATION for SPACE are NOW READY.

Applications must be made by

MONDAY, 20TH MARCH, 1922.

LIVE STOCK ENTRIES CLOSE on MAY 1st; POULTRY, RABBITS, PRODUCE, FORESTRY and HORTICULTURAL EXHIBITION on MAY 30th; PLANTATIONS COMPETITIONS on MARCH 31st.

T. B. TURNER, Secretary.

Royal Agricultural Society of England,
16 Bedford-square, London, W.C. 1,
January, 1922. 7452

East Indian Railway.

The East Indian Railway Company is prepared to receive TENDERS for the SUPPLY and DELIVERY of :—

(1) CARPENTERS' TOOLS.
(2) FILES.
(3) HANDLES (Ash, for Coal Shovels and Hammers).

as per specification to be seen at the Company's Offices.

Tenders are to be sent to the undersigned, marked "Tender for Tools," or as the case may be, not later than Eleven o'clock a.m. on Wednesday, the 1st March proximo.

The Company reserves to itself the right to divide the order, also to decline any Tender without assigning a reason, and does not bind itself to accept the lowest or any Tender.

For each specification a fee of £1 1s. is charged, which cannot under any circumstance be returned.

By Order,
O. E. LILLIE, Secretary.

Nicholas-lane, London, E.C. 4,
14th February, 1922. 7459

PUBLIC NOTICES

Madras and Southern Mahratta RAILWAY COMPANY, LIMITED.

The Directors are prepared to receive TENDERS for :—

(1) 7 STEAM HAMMERS (7½ cwt., 10 cwt., and 15 cwt.).
(2) 11 BOGIE CARRIAGE UNDERFRAMES, Broad Gauge.
1 FOUR-WHEELED BRAKE VAN UNDERFRAME, Broad Gauge.
5 FOUR-WHEELED LUGGAGE VAN UNDERFRAMES, Broad Gauge.
(3) 56 PAIRS WHEELS and AXLES, Broad Gauge,

in accordance with the specifications which may be seen at the offices of the Company. The charge for each specification is One Guinea, which will not be returned.

Tenders must be sent in, addressed to the SECRETARY, not later than 2 p.m. on Tuesday, the 7th March, 1922, marked "Tender for Steam Hammers," or as the case may be.

The Directors do not bind themselves to accept the lowest or any Tender.

Company's Offices :
25, Buckingham Palace-road,
Westminster, S.W. 1.
14th February, 1922. 7453

Manchester Corporation Water-WORKS.

THIRLMERE AQUEDUCT: FOURTH PIPE LINE.

MANUAL, AUTOMATIC AND REFLUX VALVES, &c.

The Waterworks Committee invite TENDERS for the SUPPLY of 40in. MANUAL SLUICE VALVES and AUTOMATIC STOP VALVES and 54in. REFLUX VALVES, with AIR VALVES, GANGWAYS, and other IRONWORK.

Specification, form of Tender, &c., may be obtained on application to the Secretary, Waterworks Offices, Town Hall, Manchester, upon payment of a deposit of Five Guineas, which will only be returned to the tenderer provided that he shall have sent in a bona fide Tender and shall have returned the documents and the drawings lent to him, the drawings to be unmarked. Further information, if required, may be obtained from the Waterworks Engineer.

Sealed Tenders, endorsed as directed, must be delivered at the Waterworks Offices, Town Hall, Manchester, not later than the 14th March, 1922.

By Order,
THOMAS HUDSON, Town Clerk.

Town Hall, Manchester,
14th February, 1922. 7450

The Great Indian Peninsula RAILWAY COMPANY.

The Directors are prepared to receive TENDERS for the SUPPLY of the following STORES, namely :—

No.		Fee for Specification.
1.	LAMPS AND FITTINGS	2s. 6d.
2.	FIRE-BRICKS AND FIRE-CLAY...	7s. 6d.
3.	STATION BELLS, BIB COCKS, &c.	2s. 6d.
4.	STATIONERY, &c.	10s.

Specifications and forms of Tender may be obtained at this office on payment of the fee for the specification, which payment will not be returned.

The fee should accompany any application by post. Cheques and postal orders should be crossed and made payable to the Great Indian Peninsula Railway Company.

Tenders must be delivered in separate envelopes, sealed and addressed to the undersigned, marked "Tender for Lamps and Fittings," or as the case may be, not later than Eleven o'clock a.m. on Tuesday, the 28th February, 1922.

The Directors do not bind themselves to accept the lowest or any Tender.

R. H. WALPOLE, Secretary.

Company's Offices,
48, Copthall-avenue, E.C. 2.
London, 15th February, 1922. 7454

PUBLIC NOTICES

Port of Bristol.

NEW ELECTRIC CRANES, AVONMOUTH DOCK.

The Docks Committee are prepared to receive TENDERS for the CONSTRUCTION of FOUR 30-Cwt. MOVABLE ELECTRIC JIB CRANES and the ERECTION of the same in front of Shed "A," Avonmouth Docks.

On and after Monday, the 20th February, 1922, copies of the specification and contract drawing can be obtained from the undersigned on production of a receipt showing that a deposit of £2 has been paid to the BRISTOL DOCKS COMMITTEE, 19, QUEEN-SQUARE, BRISTOL, TO WHOM ALL CHEQUES MUST BE MADE PAYABLE. The deposit will be returned to bona fide tenderers after the receipt of the Tender with all the prescribed documents and drawings.

Tenders must be enclosed in a sealed envelope, endorsed "Tender for Four 30-cwt. Electric Cranes," and addressed to the General Manager and Secretary of the Docks Committee, 19, Queen-square, Bristol, and must be delivered to him, accompanied by all the prescribed documents and drawings, before 10 a.m. on Friday, the 17th day of March, 1922.

The Docks Committee do not bind themselves to accept the lowest or any Tender.

THOMAS A. PEACE, Engineer.

Engineer's Office,
Avonmouth Docks,
15th February, 1922. 7451

Rattle Urban District Council.

FOR SALE, a Double-furnace LANCASHIRE BOILER, by Galloway, with appliances and a quantity of ARTESIAN WELL PLANT, by Isler. The same can be inspected at the Waterworks, Battle, Sussex.—Offers for purchase are invited, and should be sent to F. C. SHEPPARD, Clerk to Urban District Council, Battle, Sussex, from whom a list of the articles for sale can be obtained on application. 7426

Borough of Loughborough.

FIRE-ENGINE.

The Corporation have FOR SALE a Horse-drawn Merryweather STEAM FIRE-ENGINE, capacity 300 to 350 gallons per minute, the boiler of which needs overhauling; but with this exception the Fire-engine is in good working condition and can be seen on application at the Fire Station, Ashby-road.

Tenders, endorsed "Tender for Fire Engine," to be sent to the undersigned not later than Twelve o'clock Noon on Saturday, the 4th March next.

HARRY PERKINS, Town Clerk.

Town Hall, Loughborough,
13th February, 1922. 7434

City and County Borough of BELFAST.

ELECTRICAL ENGINEER AND BUSINESS MANAGER WANTED.

The County Borough Council of Belfast are prepared to receive APPLICATIONS for the APPOINTMENT of ELECTRICAL ENGINEER and BUSINESS MANAGER of their Electricity Undertaking.

Candidates, as well as having the necessary technical qualifications, must possess high administrative ability and have wide experience in the control and management of large electricity undertakings.

The person appointed will be required to devote his entire time to the duties of the office and be prepared to enter upon same at 1st May, 1923, or as soon there after as may be arranged.

Candidates to state salary required.

Applications must be made on official forms, which, with print of the conditions of appointment, can be had from the undersigned, with whom applications must be lodged not later than the 1st March, 1922.

Canvassing, directly or indirectly, will be considered a disqualification.

R. MEYER, Town Clerk.

7425

PUBLIC NOTICES

Borough of Wimbledon.

APPOINTMENT OF CHIEF ELECTRICAL ENGINEER.

The Corporation of Wimbledon invite APPLICATIONS for the above POSITION.

Particulars as to duties and conditions of service and form of application may be obtained from the undersigned.

Canvassing members of the Council directly or indirectly will disqualify the applicant.

Applications to be delivered to the undersigned not later than Saturday, 25th February, 1922.

A. STEELE SHELDON, Town Clerk.

Town Clerk's Office,
12, Queen's-road,
Wimbledon, S.W. 19,
8th February, 1922. 7390

London County Council.

REQUIRED, INSTRUCTORS in (a) TRADE WORK in (i.) INSTRUMENT MAKING and (ii.) MOTOR BODY BUILDING; and (b) TECHNICAL DRAWING in (i.) GENERAL TECHNICAL, (ii.) INSTRUMENT MAKING COURSES; (c) PRACTICAL SCIENCE for Technical and Trade Courses; (d) MATHEMATICS (including Arithmetic, senior, and Calculations for Technical Courses), for appointment to the panels of staff eligible for employment, as required, at evening institutions. The placing of a candidate's name on a panel is no guarantee of employment, and it is unlikely that fresh vacancies will arise before September next. Salary 15s. for two hours' teaching (20 per cent. increase paid conditionally until July, 1922, when the continuance will be considered).

Apply, EDUCATION OFFICER, T.5 "(b), New County Hall, S.E. 1 (stamped addressed foolscap envelope necessary), for Form T. 40/17 (p), to be returned by 4th March, 1922. Preference given to persons who served or attempted to serve with H.M. Forces. Canvassing disqualifies.

JAMES BIRD, Clerk of the London County Council. 7424

Singapore—Straits Settlements.

CEMENT WORKS.—CHEMIST.

WANTED for a Cement Works recently completed in Singapore, a CHEMIST, with an intimate knowledge and experience in the Manufacture of Portland Cement by the wet process, and familiar with the readiest of analyses of fuel and flue gases and all the details pertaining to the duties of a Chemist in a modern cement factory. There are two rotary kilns 125ft., mills, Griffin, tube, electric drive. Only fully experienced men need apply.

Salary £900 to £1200, according to experience, with furnished house at the works, use of motor car and bonus; four years' agreement; excellent prospects for good man.

Applications, stating age, place of birth, and giving details of education, training, and experience generally, referring particularly to the above requirements, with dates, and accompanied by copies of not more than six testimonials, must be lodged with Messrs. C. C. LINDSAY and PEIRCE, 180, Hope-street, Glasgow (who will supply further information if desired), not later than Tuesday, 28th February. 7445

Re THE COMBINED METALS AND REINFORCED CASTING COMPANY, Ltd., (IN VOLUNTARY LIQUIDATION), POINT PLEASANT WORKS, WANDSWORTH, S.W. 18.

The Liquidator is Prepared to receive OFFERS or INQUIRIES for the ASSETS of the above COMPANY, consisting of valuable ROLLING PLANT (Robertson and Co., Bedford), MACHINERY, EQUIPMENT, STOCK, &c.

Communications should be addressed to the Liquidator,

MAURICE JENKS, F.C.A.,
6, Old Jewry, E.C. 2. 7464

SITUATIONS OPEN

7352 WISH to THANK all APPLICANTS for their APPLICATIONS for post advertised, and to inform all who have not been communicated with direct that their applications have been considered but are not acceptable. 7448 A

WANTED, ENGINEER, Designer and Estimator, with knowledge of advertising and general propaganda work, by north country crane firm. State experience, age and salary.—Address, P4930, The Engineer Office. P4930 A

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SITUATIONS OPEN (continued)

A FIRM of IRON and STEEL MANUFACTURERS in South Wales REQUIRE a practical MAN (30 to 40 years of age) as CHIEF WORKS ENGINEER. Must have had previous experience in a similar capacity and be fully conversant with the running of Blast-furnaces, Steel Works, Rolling Mills, and subsidiary plants. State age, experience, and salary required in strict confidence.—Address, 7326, The Engineer Office. 7326 A

CORRESPONDENCE SALESMAN for Standard Buildings and Roofs. Able to sketch, plan, and estimate. Adaptability essential.—Write fully, giving experience, "ACCOUNTANTS," c/o Pool's Advertising Service, 180, Fleet-street, E.C. 4. 7407 A

CRANE DESIGNER.—A Leading FIRM of CRANE BUILDERS in the North DESIRES to MEET with a GENTLEMAN throughly qualified in the Designing of Steel Works Charging and Overhead Cranes. One preferred who can estimate costs, conduct correspondence and interview customers. Particulars, in confidence, regarding experience and salary.—Address, 7431, The Engineer Office. 7431 A

ENGINEER REQUIRED for Estimating and Negotiating Contracts and carrying these through to completion. Public school and university man preferred. Practical training and knowledge of design of Surface Condensing Plants absolutely essential. Should be experienced and competent salesman with good connection, whose chief duties would be to promote energetically the sale of machinery of this character.—Address, giving full particulars, with age and salary required, 7430, The Engineer Office. 7430 A

IRONFOUNDERS, Producing About 1000 Tons of castings per week, largely repetition work, with semi-skilled and skilled men, REQUIRE the SERVICES of capable WORKS MANAGER having up-to-date experience in Patternmaking, Moulding and Machining.—Address, stating age, experience, and salary desired, to P4955, The Engineer Office. P4955 A

MECHANICAL ENGINEER, Unmarried, 30/35, thoroughly trained railway shops, as ASSISTANT to CHIEF MECHANICAL ENGINEER, Central American railway. Knowledge Spanish preferred.—Write, "R. V.," c/o J. W. Vickers and Co., 144a, S. Nicholas-lane, E.C. 4. 7429 A

REPRESENTATIVE REQUIRED, for London and South by a well-known Firm of Steam Wagon Manufacturers to Sell their Specialities.
Preference will be given to a real live man with a connection in this area. None but experienced men need apply.
Applications must state age, experience, and salary required. Copies of testimonials only and not originals. Applications will be treated with strict confidence.—Address, 7470, The Engineer Office. 7470 A

REQUIRED by Old-established Engineering Firm in India, experienced SALESMAN for Engineers' Stores and Hardware. Single, age about 25, of good address and public school education.—Reply fully, stating age, experience, and present salary, to Z. O. 794, c/o Deacon's, Leadenhall-street, E.C. 3. 7449 A

SMART COMMERCIAL ENGINEER WANTED, about thirty, to Sell Heavy Pulverising Mills. Only capable men with good selling record need apply. Must be good correspondent. Good connection and experience with collieries, cement, and chemical manure works an advantage. Languages also advantageous. Write fully, stating salary required, when free, &c.—Address 7388, The Engineer Office. 7388 A

WORKS MANAGER for Boiler and Constructional Engineering Works (Ltd. Co.). Must be well up in this class of work and able to take charge under director. Preference given to one able to invest £500 to £1000 in sound progressive business.—Address in confidence, with full particulars of experience, age, &c., to 7456, The Engineer Office. 7456 A

WORKS MANAGER REQUIRED for Large Structural Works (old established) in the Midlands, capable of an output of 1000 tons per month. Exceptional opportunity for an experienced energetic man with organising ability. Preference given to man having also a commercial knowledge.—Address in first instance, stating age, experience, and salary required, 7460, The Engineer Office. 7460 A

WANTED, DRAUGHTSMAN, Experienced in Gasworks and by-product plant practice.—Address, stating experience, age, and salary expected, 7462, The Engineer Office. 7462 A

WANTED, TWO First-class DRAUGHTSMEN, accustomed to Gasworks Practice, Chemical Plant, and General Constructional Engineering Work.—Address, stating age, experience, salary required, and giving references, 7385, The Engineer Office. 7385 A

CRANE DRAUGHTSMAN WANTED for Manchester district; knowledge of Structural Work an advantage.—Address, stating age, experience, and salary required, 7432, The Engineer Office. 7432 A

DRAUGHTSMAN, AERIAL ROPEWAYS.—First-class MAN WANTED, accustomed to Preparing Schemes and Tenders.—Apply, stating age, experience, wages required, when free, to Chief Draughtsman, JOHN M. HENDERSON and CO., Aberdeen. 7455 A

JUNIOR DRAUGHTSMAN REQUIRED for High-class Firm of Heating and Ventilating Engineers.—Write, stating age, salary, and experience, to Box 737, Samson Clark and Co., Ltd., 58, St. Portland-street, W. 1. 7417 A

SENIOR DRAUGHTSMAN, First-class Man, Used to highest grade Cars and Water-cooled Aero-engines, for firm in London district.—Address, giving particulars of previous experience and salary required, P4929, The Engineer Office. P4929 A

SHIPS' DRAUGHTSMAN WANTED, Having Long and wide experience in the Design of Small Craft, Paddle Boats, Stern-wheelers, Launches, Dispatch Boats, &c. Applicant would require to do his own drawings and calculations and should not be under 40 years of age. Give full details and state salary required.—Address, 7448, The Engineer Office. 7448 A

FOREMAN MECHANIC.—WANTED, First-class MAN to Take Charge of Maintenance and Repairs of Machinery, Boilers, and Steam Mains in a large factory in London. Must have sound workshop training and used to control of men.
Apply by letter, giving full particulars, to Box 77, c/o Gosden's, 11, Henrietta-street, Covent Garden, W.C. 2. P4937 A

FOREMAN, Working, REQUIRED for Charge of Small Engineering Shop in London (West). Good organiser and disciplinarian. Must be first-class tool fitter. Permanent job.—Address, stating experience and salary, 7441, The Engineer Office. 7441 A

SITUATIONS WANTED

A M.I. Mech. E. REQUIRES APPOINTMENT. General experience England and Africa, pumping, surveying, ferro-concrete, first-class draughtsman. Good refs.—Address, P4936, The Engineer Office. P4936 B

BUYING ENGINEER.—The MANAGER of a Large Engineering Works Purchasing Dept., who has an exceptionally wide knowledge of the markets of the country, DESIRES to NEGOTIATE NEW APPOINTMENT.—Write, Z. M. 619, c/o Deacon's, Leadenhall-street, E.C. 3. 7393 B

CHEMICAL ENGINEER and METALLURGIST DESIRES POST with firm who could make use of his knowledge; expert in the recovery of waste products.—Address, P4943, The Engineer Office. P4943 B

SITUATIONS WANTED (continued)

ADVERTISER, M.I. Mech. E., Now Disengaged, DESIRES POSITION as WORKS SUPERINTENDENT or MANAGER.
Exceptional knowledge of mass production methods. Six years as assistant and over eight years as works manager with large firm engaged on accurate interchangeable work. Salary required about £600 per annum.
Extract from recent testimonial from well-known engineer, a previous employer:—
"I have no hesitation in saying that Mr. —— would be invaluable in managing or reconstructing an engineering works manufacturing intricate products requiring fine limits. I can speak highly of his courtesy, hard work, and general ability."
Please address, P4954, The Engineer Office. P4954 B

ENGINEER, A.M.I. Mech. E. (35), Late R.E. officer, REQUIRES APPOINTMENT; 14 years' good all-round engineering experience, works and office, good organising abilities.—Address, P4942, The Engineer Office. P4942 B

ENGINEER, A.M.I. Mech. E., REQUIRES APPOINTMENT, home or abroad; 15 years' practical and theoretical experience of large collieries, design, lay-out, sinking and equipment, &c.—Address P4765, The Engineer Office. P4765 B

ENGINEER, Assoc. M. Inst. C.E., DESIRES POSITION of CONFIDENTIAL ASSISTANT to Managing Director. Advertiser has served a thorough apprenticeship alongside skilled tradesmen, possesses sound knowledge of modern manufacturing methods, has had experience of labour under present-day conditions, and can claim to be well versed in works organisation and procedure. Theory at univ.; age 36.—Address, P4939, The Engineer Office. P4939 B

ENGINEER, B.A. (Cambridge), SEEKS POST, Manager or Assistant Manager. Accustomed to mass production in non-ferrous metals, correspondence and planning.—Address, 7446, The Engineer Office. 7446 B

ENGINEER, British (29), Good Experience and references, holding B.O.T. certificate, experienced in turbines, all class of boilers, either coal or oil fuel, steam engines, pumps, &c. Capable of managing men, held positions of trust and responsibility, REQUIRES BERTH, home, Colonies or abroad.—Address, P4914, The Engineer Office. P4914 B

ENGINEER (22), 4½ Years' Pupil, Vickers Limited, drawing-office experience, SEEKS POSITION at home or abroad; willing to accept small salary.—Address, P4957, The Engineer Office. P4957 B

ENGINEER (32), O.B.E., M.C., A.C.G.I., B.Sc. (Eng.), Lond., A.M.I.C.E., M.C.I., 3 years P.W.D., India, 4 years war service in France, 3 years building and engineering contractor, London, with good business experience and ability, DESIRES progressive APPOINTMENT; would invest if required.—Address, P4911, The Engineer Office. P4911 B

ENGINEER (34) DESIRES POSITION, Works or Chief Engineer (Mechanical). Held similar position; had considerable experience in steam and electrical, sea and ashore. Good reference.—Address, P4917, The Engineer Office. P4917 B

ENGINEER MECHANIC (40), Experienced in Plant lay-out and general engineering, DESIRES responsible POSITION near London. Can take complete charge of plant and do all running repairs.—Address, P4908, The Engineer Office. P4908 B

EXPERT LOCOMOTIVE ENGINEER, A.M.I. Mech. E. (44), DESIRES CHANGE, home or abroad. Specialist in costing, organisation and production.—Address, P4919, The Engineer Office. P4919 B

HAVING Considerable Commercial (Sales and Buying), technical (D.O., workshop and inspecting) experience, ENGINEER (27), public school education, desirous of improving his position, would like to hear of VACANT POST where he could use his full ability. Sound reference.—Please address, P4867, The Engineer Office. P4867 B

IRONFOUNDRY MANAGER or GENERAL FOREMAN (36) SEEKS RE-ENGAGEMENT; capable of taking sole control, good knowledge of up-to-date foundry practice, including piecework, mixer, and good organiser; excel. refs.—Address, P4926, The Engineer Office. P4926 B

MECHANICAL ENGINEER, with Good All-round general experience as foreman, cost clerk and manager, SEEKS responsible POST in any capacity, any district.—SNOAD, 36, York-road, Hitchin. P4942 B

OIL TANK ERECTOR, BOILERMAKER, and GENERAL STRUCTURAL ENGINEER, just returned from the East (late tank erector to large oil company), REQUIRES POSITION at home or abroad, good knowledge of Hindustani and used to handling all types of Eastern labour.—Address, P4956, The Engineer Office. P4956 B

ORGANISER of Proved Ability, M.I. Mech. E., DESIRES POST in advisory capacity. Wide commercial and manufacturing experience at home and abroad. Moderate salary and bonus according to results.—Address, P4959, The Engineer Office. P4952 B

TWO DIRECTORS.—GENTLEMAN (40), M.I. Mech. E., with wide and varied experience in works management, production and general management, DESIRES highly responsible and progressive POST. Capable of relieving a board of directors from many worries and getting satisfactory results. Has successfully controlled work employing 5000 hands and really obtained economic production. Thoroughly versed in sales organisation, estimating and all departments necessary for successful business. For last three years assistant general manager of a large and well-known firm. Credentials furnished of the highest character. Moderate salary.—P4827, The Engineer Office. P4827 B

YOUTH, 18½ years, just left Public School, Special science course, SEEKS JUNIOR POST in Chemical or Physical Laboratory. Amount of salary not of first importance.—Address, P4959, The Engineer Office. P4959 B

WORKS MANAGER DESIRES Similar POST or as ASSISTANT in large concern. Advertiser has special knowledge of progress work, is experienced in modern methods, and has had sound practical and technical training.—Address, P4940, The Engineer Office. P4940 B

WORKS MANAGER DESIRES CHANGE. Advertiser has an established reputation as organiser and economist, is experienced in the control of fully equipped engineering works, and is prepared to accept a moderate salary supplemented by a reasonable share of profits.—Address, P4918, The Engineer Office. P4918 B

WORKS MANAGER REQUIRES POSITION. Wide experience all branches, tactful organiser, proved record; home or abroad.—Address, P4923, The Engineer Office. P4923 B

ASSIST. ENGINEER and DRAUGHTSMAN (29), works, marine, constructional, B.O.T. and college certificated, experienced supervisor in excavating, building, running and repairs of all plants, DESIRES responsible POST, home or abroad.—Address, P4946, The Engineer Office. P4946 B

DRAUGHTSMAN, Fully Qualified, Wide Experience, DESIRES PRIVATE WORK. All work strictly confidential.—Address in first instance, P4922, The Engineer Office. P4922 B

SITUATIONS WANTED (continued)

DRAUGHTSMAN (23), 5 Years' Exp. Rly. Carr. and wagon, rly. sidings, points, switchgear, road works lay-out, secondary school education, ACCEPT POST anywhere on earth. Keen and ambitious.—Address, P4947, The Engineer Office. P4947 B

DRAUGHTSMAN, 9 Years' Experience in Design and lay-out of plant, also steam and oil engine design. Diploma and certificates; excellent references.—"G.," 24, Courtney-road, Waddon, Surrey. P4935 B

DRAUGHTSMAN-MECHANICAL ENGINEER. Experienced man, technically trained, DESIRES POST, marine engineering, steam and oil engine experience.—Address, P4915, The Engineer Office. P4915 B

JUNIOR DRAUGHTSMAN (18), Sound Practical and technical training, 12 months D.O., good tracer, SEEKS SIT.—MACKAY, 257, Amhurst-road, Stoke Newington, N. P4939 B

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For continuation of Small Advertisements see page iii

300-Ton Ice Factory at Grimsby.

WHAT is described, we believe quite correctly, as being the largest electrically operated direct expansion ice-making plant in the world has recently been erected and put to work at Grimsby for the Standard Ice and Cold Storage Co., Limited, by the Pluperfect Refrigeration Co., Limited, of 49, Deansgate, Manchester.

Comparatively few people outside the fishing ports realise the large part played by ice-making machinery in connection with the trawling industry. Grimsby, or Fishopolis, as it is sometimes termed, is a town of 80,000 inhabitants situated at the mouth of the river Humber. It is dependent upon the industry for its existence, and it is justly proud of the fact that it is the largest fishing port in the world. Visitors to the town for the first time are somewhat astonished when told that over 1000 tons of ice can be manufactured, crushed and delivered to the trawlers daily.

Ice making in Grimsby commenced during the 'seventies, when a small absorption plant, having an output of 100 tons per week, was installed in Victoria-street, and although that plant is not in existence today, it was the beginning of what is at the present time one of the principal industries of the town. During the year 1895 the Linde British Refrigerating Company, Limited, decided to lay down a plant in Robinson-street with a capacity of 100 tons per day, and the building was commenced in June, 1896; but before the factory was completed the Linde Company disposed of its interest in the scheme to Messrs. Hagrup, Doughty and Co., now the Consolidated Steam Fishing and Ice Company, Limited, and the installation had only been in operation a very short period before an extension was decided upon and a 200-ton plant was erected in the year 1898, making a total output of 300 tons per day.

About the same time the ice problem was being considered seriously by various trawler owners, with the result that during 1899 the Great Grimsby Co-operative Ice Company, Limited, built in the Fish Docks a new factory for an output of 300 tons per day, and commenced ice making in October, 1901. The factories were eventually being pushed for output, and during 1905 and 1906 the shortage was acute. The Grimsby Co-operative Company, Limited, then decided to erect a new factory to give an additional output of 200 tons, which brought the firm's capacity for making ice up to 500 tons per day, whilst a few years later certain improvements were carried out in connection with the plants, which increased the total output to 600 tons per day, and that, together with the Consolidated Steam Fishing Company's 300-ton output, was, during the years 1913 and 1914, found quite inadequate to meet the demands of the fleets using the port.

During the period of the Great War the trawling industry was curtailed, and only a comparatively small quantity of ice was used; but the possible requirements of the industry at the conclusion of hostilities was in the mind of at least one of the principal trawler owners and fish merchants of the town, Mr. W. F. Goodwin, and he lost no time in convincing his friends of the necessity of further ice-making facilities being provided, with the result that in August, 1919, Mr. A. C. Davis, A.M.I. Mech. E., in company with Mr. Frederick Ryder, managing director of the Pluperfect Refrigeration Company, Limited, met Mr. Goodwin in Grimsby and was commissioned to submit plans and specifications for an up-to-date plant capable of producing 300 tons of ice per day and as much cold storage space as could be suitably dealt with on the site.

In collaboration with Mr. E. Goodhand, architect, and Mr. E. O. Williams, constructional engineer, a building having a frontage of 176ft. on Victor-street, with a depth of 140ft., was designed. The main building is constructed entirely of reinforced concrete, with the exception of brick filling between the concrete columns, and it consists of two floors and a large water storage tank of concrete above the roof.

Serious consideration had to be given to the question of proper facilities for disposing and transporting the ice after crushing, and it was eventually decided to employ a fleet of electric lorries between the factory and the docks. It was estimated that each lorry would be able to do six journeys per day with five-ton loads, so that, with two of the vehicles acting as stand-bys, twelve lorries would be required to handle the output of 300 tons per day; but in actual practice much more favourable results have been maintained. We may say, incidentally, that we are informed that the electric vehicles have given very little trouble during the six months the factory has been in operation, and that the cost per ton of ice delivered is lower than would have been the case had petrol wagons been employed. The consumption and cost of power is very low owing to the arrangements which have been made for the batteries to be re-charged at any time in the factory.

To enable the quick filling of the bags of ice, five ice crushers were fixed at the south side of the building. They discharge the ice into hoppers on to a platform at the ground level, where the bags are filled as rapidly as the human element will allow. Although the full output of 300 tons has not yet been bagged in one day, it is anticipated that when the time comes for the full complement to be handled, the 300 tons of ice will be drawn from the ice tanks, crushed, bagged and delivered to the trawlers inside of ten hours without any difficulty. The lorries coming in from the back of the building are loaded and then drive out by the front gates, so that no congestion can take place, which would no doubt have occurred had a through road not been possible.

Water supply was another problem which had to be faced, and it was eventually decided to sink two artesian wells at opposite corners of the site. The bore in each case was 14in., but whilst the well at the north side was put down 250ft., the south bore was sunk to 300ft. In each case an abundance of pure water was found, the yield being over 30,000 gals. per hour from each well. The bore-holes are lined with 12in. tubes to a depth of 100ft., with a 2in. internal air pipe, and the pressure is obtained from air compressors placed in the machinery room; 100 lb. pressure is require to raise the water, but this pressure drops to 80 lb. immediately the flow of water is started. The discharge from both wells is carried to the roof of the building into a reinforced concrete tank which has a capacity of 700 tons, from which is taken the main supply to the sixty ice tanks, each of which is directly connected to the water main and can be filled at the rate of two tons per minute.

At the north end of the building is the entrance to the cold stores, which consist of a number of chambers on the ground level, of a total capacity of 150,000 cubic feet. The chambers are cooled by the direct expansion of ammonia, the cooling coils being fixed on the ceiling of the chambers. At the south side is provided a sharp freezer for wet fish, the direct expansion coils in its rooms being arranged in the form of shelves about 9in. apart. The insulation of the cold stores on the sides, ceiling beams and columns is of slag wool packed at 16 lb. to the cubic foot, whilst the floors are covered with two layers of 3in. cork board laid in bitumen and finished with two layers of asphalt. Dunnage battens are fixed on

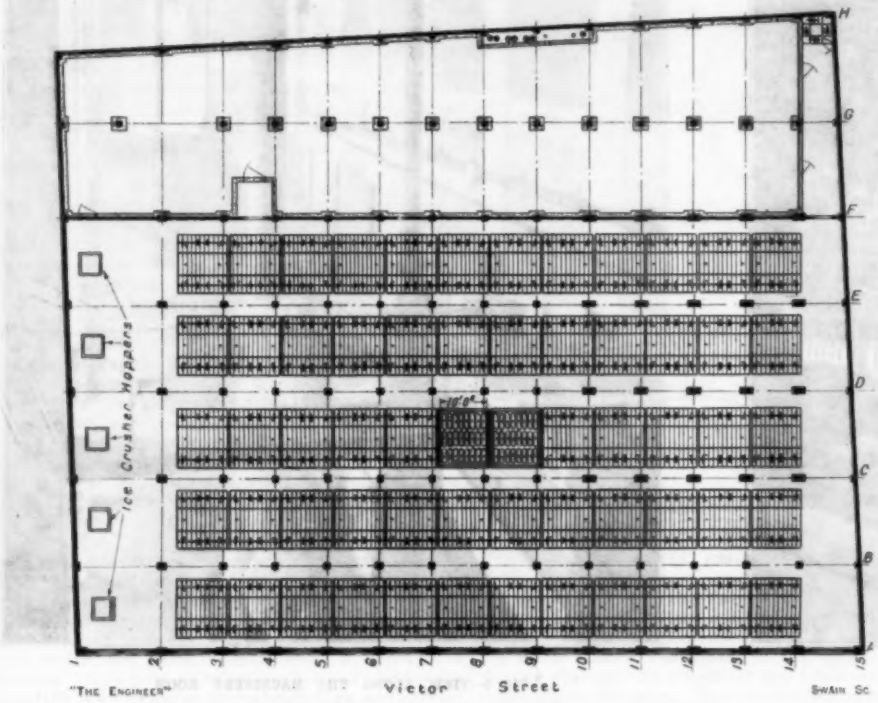


FIG. 1—PLAN OF FIRST FLOOR OF FACTORY, SHOWING ICE TANKS

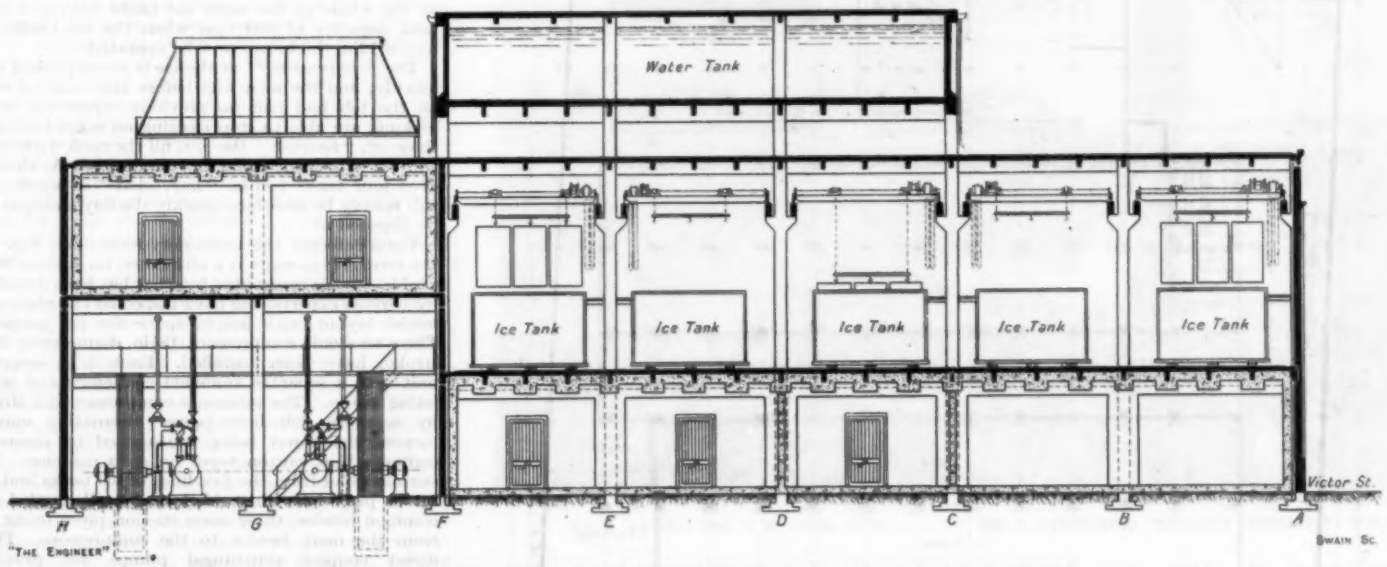


FIG. 2—CROSS SECTION THROUGH MACHINE ROOM, ICE TANK FLOOR AND COLD STORES

the sides of all the chambers spaced 12in. apart.

The ice tanks are immediately over the cold stores. There are on the one floor sixty standard 10-ton Pluperfect ice tanks arranged in five rows of twelve tanks. Each row of tanks has a 2-ton electric crane for "harvesting" purposes.

The Pluperfect system of ice making is a departure from the systems in operation at the other factories simply forms round the grids and the arrangements are such that when the blocks are 12in. thick there is a space of 3in. of water between each block.

When "thawing off" is required, one of the tanks is closed down, and the liquid ammonia from the condenser is passed through the grids on its way to the tanks which remain in operation. Thus the latent heat of the ice is utilised in "thawing off" to cool the of the cold room, the 10-cwt. blocks being quite easily handled and stowed, as will be seen in one of the illustrations in our Supplement, which also shows the runways over each line of blocks.

Owing to unavoidable delays in obtaining possession of part of the site the completion of the building was delayed several months, but it became imperative that ice production should be commenced

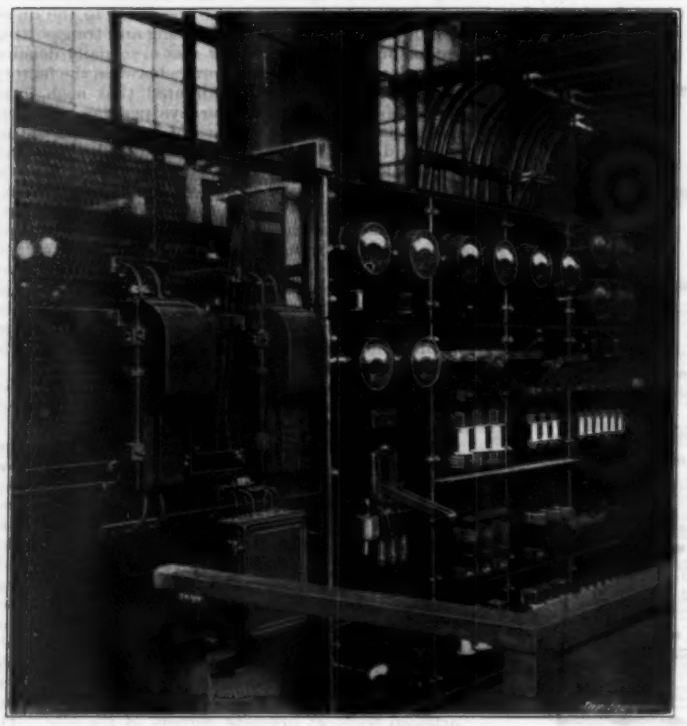


FIG. 3—LOW TENSION SWITCHBOARD

FIG. 4—VIEW ALONG THE MACHINERY ROOM

in the town. The ice tanks are constructed out of heavy timber, and they contain a number of single vertical grids of tubes, the number and pitch of the grids being regulated by the quantity and size of ice blocks required; 6ft. 6in. by 3ft. 9in. by 11 cwt. may be taken as a very general size. For blocks of this size, the pipe grids are placed at 15in. centres. The grids themselves are made out of D section steel tubes, welded together along their flat face, each pair being equal to tubing having an outside diameter of 1in. The top end of each double tube has a cap welded on to it which acts as a return bend for the ammonia gas. The lower end of each half of the double tube is coupled in series to the grid next to it, and so on. The whole then forms one complete evaporator for the expanding refrigerant. It will be understood that no moulds are used. The ice liquid refrigerant, and sensible heat which would otherwise neutralise a part of its refrigerating effect at the expansion valves is extracted from the refrigerant, an arrangement which effects a considerable economy. The ice when "harvested" is all carried to one end of the building, where an ice crusher is fixed in line with each row of tanks, five in all.

The crushers are driven from a line shaft, which receives its power from a 100 horse-power motor, the driving gear all being installed on an intermediate floor under the ice crushers and over the cartway.

When ice is being harvested and is not required for crushing, the blocks are delivered by the cranes on to the platform, where they are packed up and transported into the ice stores, which are capable of containing over 1600 blocks of ice, by means of a series of runways fixed over the platform and on the ceiling

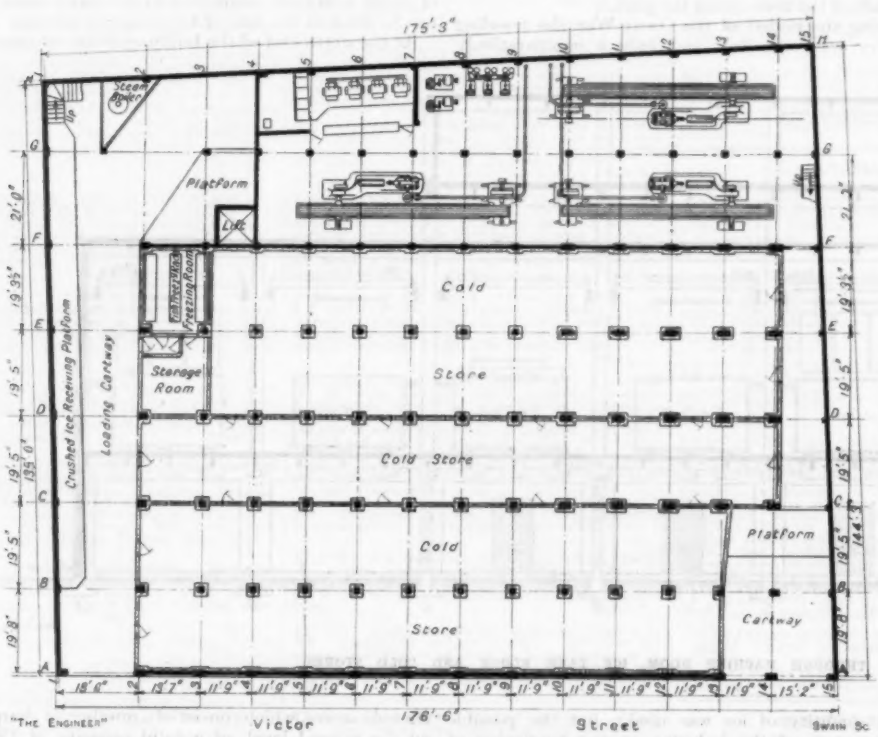


FIG. 5—GROUND FLOOR PLAN, SHOWING MACHINERY ROOM, COLD STORES AND FISH FREEZING ROOM

with part of the plant, and the Pluperfect Refrigeration Company, Limited, arranged to erect twenty-five of the sixty ice tanks and to get one of the plants to work, notwithstanding the fact that the ice tank room was at that time open to the streets.

The work was pushed forward and the first unit was ready to run early in April last. Then, however, the contractors encountered other people's troubles in connection with the starting up of a turbo-generator at the local power station; but all difficulties were eventually overcome, and it was possible to commence ice making at the rate of 100 tons per day on July 20th, 1921. That output was increased to 200 tons per day during the month of September, and the plant is now completed and ready for its 300 tons per day, as the whole of the sixty ice tanks having a total tank capacity of 600 tons when the ice blocks are frozen 12in. thick, can now be operated.

The "harvesting" of the ice is accomplished very quickly, and the men who before they started work on the job had had no previous experience in ice making, are able to stop freezing on a ten-ton tank, thaw off, "harvest" the ice, fill the tank with water and set it to work again in 40 minutes. As three or even four tanks can be "harvested" at one time, it will readily be seen how quickly the day's output can be disposed of.

Upon entering the machinery room—see Fig. 4—the term engine-room is a misnomer, no engines being visible—one is confronted by what has been described by various experts who have inspected the plant as a model layout with ample space for all purposes. Three ammonia compressors, 18½in. diameter by 36in. stroke, have been installed. Each is a complete unit with a separate ammonia condenser and circulating pump. The ammonia compressors are driven by separate 300 horse-power alternating current motors, the power being transmitted by means of eighteen 1¼in. cotton ropes on each machine. The suction pipes from the five lines of ice tanks and the return pipes from the cold stores are all coupled to a common header, three main suction pipes being run from the main header to the compressors. Three direct coupled centrifugal pumps are provided for circulating the cooling water over the condenser, the connections being arranged to allow either of the pumps to work on any of the three condensers. Two duplex coupled air compressors are also fixed in the machinery room for air supply to the artesian wells. The ammonia condensers, which are placed on the roof of the building, consist of three entirely separate units, but they are so arranged that either condenser can be operated with any of the ammonia compressors.

For the electrical equipment the current is taken from the Corporation supply into high-tension switch cubicles at 6600 volts, 50 cycles, three phase, and from thence through ring mains and outgoing switches to three single-unit transformers, 1000 k.V.A. 6600/415 volts oil cooled, connected to the low-tension

switchboard by means of multiple bus-bars. The transformers are delta-connected on the high-tension side and star-connected on the low-tension side. There is also one spare transformer, which, in the event of one unit failing, can be put into action in a very short time and a minimum of trouble, as the bus-bars are arranged in such a manner as to make all connections interchangeable with those on the spare unit.

The low-tension switchboard contains on panel No. 1 one 2000-ampère main switch, oil immersed, totally enclosed, and fitted with no-volt release, and three overload coils, three ammeters, one voltmeter and two earth indicators. No. 2 panel has two 500-ampère triple switches and fuses. No 3 panel has one 500-ampère and two 200-ampère triple switches and fuses, and No. 4 panel has four 100-ampère triple switches and fuses, all with the necessary ammeters.

In the machinery room there are three 300 horse-power motors for driving the three compressors. These motors are of the slip ring induction type, and are fitted with brush lifting and short circuiting gear. The machines are started as slip ring machines, and when they attain full speed the brushes are lifted and the rotor is then short circuited upon itself, and runs as an induction machine. All the switch gear is oil immersed, totally enclosed, and is furnished with interlocks, overload and no-volt coils. The driver cannot start a motor until the brush gear is in correct position. The rotor starters are oil immersed with "on" and "off" positions for the electrical interlocks. The starter has to be in the "off" position before the driver can close the switch. The two 80 horse-power motors for the air compressors are also of the slip ring induction type fitted with similar protective devices to those of 300 horse-power machines. The switch gear is similar to that of the larger machines. There are also three 17 horse-power squirrel cage induction motors for driving the circulating pumps. The starters are star-delta connected, and are fitted with overload and no-volts coils. The lift is driven by a 20 horse-power slip ring motor, controlled by contactor gear operated from the cage. The five cranes are each fitted with two motors of the slip ring type—2 horse-power for travelling and 8 horse-power for lifting—which are controlled from the platforms, each crane being protected by a triple pole switch and fuses. Each circuit is wired to a five-way triple-pole distribution box, of Admiralty type, the cable being of the cab-tire type and carried in porcelain cleats. The two blower motors are of 17 horse-power capacity and of the squirrel cage type, with star-delta starters fitted with overload and no-volt release. The 100 horse-power motor for driving five ice crushers is of the slip ring induction type, and is fitted with similar brush lifting and short-circuiting device and protective gear to that of 300 horse-power machines All the mains are carried in cable racks supported by angle iron framework.

The current for lighting, which is at 100 volts, is obtained from a 6600/100 volts three phase and two phase oil-cooled transformer. The low-tension phases are wired into a double-power switch and fuses, each phase having a section box of its own. No. 1 phase, which feeds the ground floor, supplies eighteen half-watt 100 candle-power lamps in the engine-room, ten half-watt 100 candle-power lamps in the covered roadway, and forty 32 candle-power lamps in the cold store. All the wiring on the lighting circuits is effected with cab-tire cable fixed in cleats. No. 2 phase, which feeds the tank room, supplies thirty half-watt 100 candle-power lamps, the fittings for which are of the U-seal type, the ceiling fittings and lamp holders being of porcelain and designed in such a manner as to be filled with a special oil to make them safe against damp. In the ice store there are sixteen 60-watt lamps, and there is a pilot lamp outside each chamber. All the distribution boxes are of the Admiralty pattern, and are fitted with water-tight glands.

The contract for the complete equipment of the factory was placed with the Pluperfect Refrigeration Company Limited, 49, Deansgate, Manchester, and the erection of the plant was carried out under the personal supervision of Mr. A. C. Davis.

The sub-contractors for the machinery, &c., were :—For the electric motors and switchgear—The General Electric Company, Limited, of Witton, Birmingham ; for the high-tension cubicles and transformers—Metropolitan Vickers, Limited, of Trafford Park, Manchester ; for the electric cranes and runways—Herbert Morris, Limited, of Loughborough ; for the ammonia compressors and condensers—The Lightfoot Company, Limited, of London ; for the air compressors—Reavell and Co., Limited, of Ipswich ; for the insulation of the cold stores—Wallington Jones and Co., of London ; for the electric wiring, &c.—James Scott, Limited, of Bootle, Liverpool ; for the ice crushers—Pertwee and Back, of Yarmouth ; and for the artesian wells—J. Smith and Co., of Grimsby. The building was erected by Messrs. William Townson and Sons, of Bolton, Lancs.

THE Chinese Ministry of Communications is preparing to install a long-distance telephone between Peking and Harbin *vid* Fengtien and Tientsin, which will be in operation this year.

A Scottish Hydro-electric Plant with Pumped Storage.

A WATER-POWER installation possessing many novel features has lately been put into operation for the purpose of driving the Tweedvale and Tweedholm Mills at Walkerburn, Peeblesshire.

Before describing the arrangement of the plant it may be mentioned that the village of Walkerburn became a thriving community when the two mills were established by different proprietors in 1854, and that the mills owed their inception to the water power

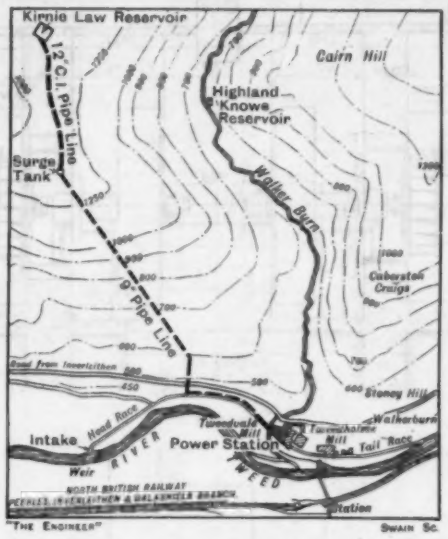


FIG. 1—POWER HOUSE, RESERVOIR AND PIPE LINE

that was available in the Tweed. For a long time this source of power was the only one used in the mills. The fall available was divided between the two mills, the water leaving the wheels of the upper mill and passing through the wheels of the lower mill before returning to the river. The falls utilised were respectively 5ft. 3in. and 5ft., for although the total head between the intake and the point of return to the river was 15ft., nearly 5ft. was lost in the long head and tail races. The mills covered a considerable area, and long ago outgrew the power available from the old breast wheels, which together yielded only about 110 horse-power. Other means of driving had therefore from time to time been added to supplement the water power. Nevertheless, a great loss of power in its transmission to the scattered buildings by means of long lines of shafting and bevel gearing was unavoidable.

Full development of the water power was impossible until the ownership of the rights for the whole of the fall passed into the hands of one owner. When, therefore, Henry Ballantyne and Sons, Limited, the owners of the Tweedvale Mills, purchased the Tweedholm Mills in July, 1918, they decided to utilise the water available to the best advantage and to eliminate the heavy losses of transmission by introducing electrical driving. Boving and Co. (London), Limited, were asked to prepare a suitable scheme, and their proposals were adopted.

The first point decided was that the power obtainable from the available head should be developed at one place, the obvious advantages being that an economical head was secured for driving the turbines, while the duplication of the plant and operating staff was avoided. It was settled that the fall should be concentrated at the upper mill by deepening the race between the two mills, as it was impossible to concentrate it at the lower mill without flooding the intermediate buildings. This plan involved a considerable amount of excavation. The head anticipated was 10ft. 6in., but additional improvements in the hydraulic conditions were subsequently made, with the result that the operating head is now, under normal conditions, slightly over 11ft. The size of the existing races was such that their carrying capacity was limited to about 240 cubic feet per second, and it was not found economical to increase their dimensions. Whilst this quantity of water is normally available throughout the year, there are especially dry years when the flow falls below that figure, so that any expenditure in increasing the capacity of the races was not desirable.

The power available under the conditions stated above is 220 horse-power, which, it will be noted, is exactly double that given by the old breast wheels. A survey of the power requirements of the two mills showed, however, that a total of 450 horse-power was required. The problem therefore became how to find the balance of 230 horse-power. The mills work for about fifty hours per week, so that for two-thirds of the week the power available would not be wanted. With such a low head as 10ft. 6in. the storage of the water was quite out of the question, because the quantity to be stored would have been so great that it would have involved the flooding of valuable lands. Electrical storage of the surplus power was also deemed impracticable, and it was finally decided to store the power mechanically in accordance with the following plan. During the idle hours the turbines were to be run for the purpose of driving pumps, the water from which was to be delivered to a high-level reservoir and there stored for use during the working hours. During these working hours the water would run down from the high-level reservoir through the same pipe as it previously flowed up through, and by driving a Pelton wheel would generate the extra power required.

A survey of the conditions proved that this scheme was quite practicable, for the hills immediately behind the mills rose up steeply to a height of over 1000ft., and offered an ideal site for the contemplated reservoir. In Fig. 1 a general plan of the site is given, and shows the two mills standing on the mill lade close to the bank of the Tweed, and the positions of the reservoir, the 12in. cast iron pipe line, the surge tank, and the 9in. steel-riveted pipe line. The 9in. high-pressure pipe line, to save expense, was brought as steeply as possible down the hillside. The reservoir had to be placed on a saddle some little distance away, and was connected to the top of the high-pressure pipe line by a 12in. cast iron pipe running practically on the level round the contour of the hill. A surge tank was necessary at the junction point to provide or absorb water at times of change of load, for the 9in. pipe being more steeply sloped would more readily accommodate itself to changes of load, and on increasing loads would draw off more water than the 12in. pipe could immediately supply.

This scheme provides the extra 230 horse-power required, for, in spite of the fact that a good deal of the energy available during the idle hours is absorbed in providing power to operate the pumps, and in

FIG. 2—LAYING THE 9 IN. PIPE LINE

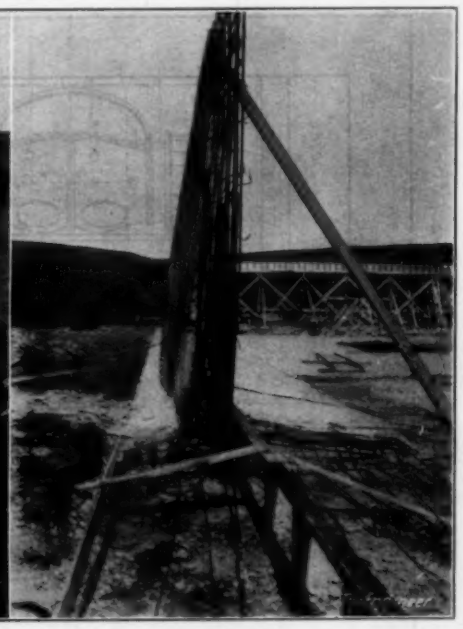


FIG. 3—REINFORCED CONCRETE RESERVOIR WALL

HYDRO-ELECTRIC PLANT AT WALKERBURN, PEEBLESSHIRE

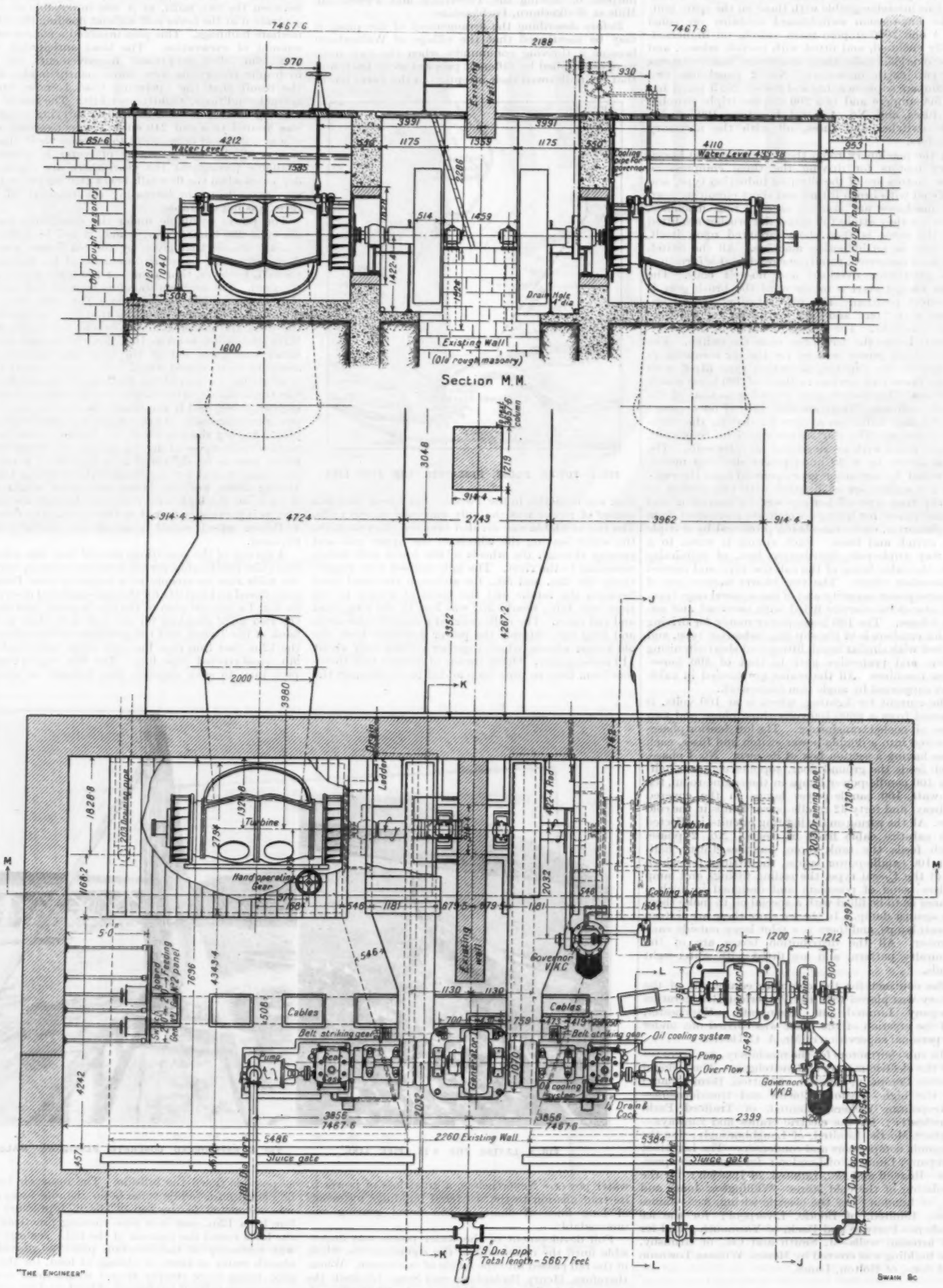


FIG 4—GENERAL ARRANGEMENT OF THE POWER HOUSE

pipe friction, the fact that the idle hours are more than the working hours fully compensates for these losses and enables the effective power to be more than doubled.

Having described the scheme in outline, we now turn to the more important details. The general arrangement of the power house is shown in Fig. 4, whilst various sectional elevations are given in Fig. 5. The low-pressure power units consist of two large double-runner horizontal Francis turbines of 110 horse-power each, running at a speed of 200 revolutions per minute. It will be seen that between the turbines a water-tight chamber is left. Each turbine is fitted with a large belt pulley of double width and 100in. in diameter. The outlets from the turbines are inclined at an angle in order to reduce the disturbance of existing buildings, and also to give a cleaner exit for the water. Both the low-pressure turbines drive on to a single generator of 145 kilowatts running at 600 revolutions per minute, each end of the generator shaft having an overhung crowned pulley for the purpose.

Under normal conditions the low-pressure turbines are run with hand control. During the day all variations in the demand are met by means of the high-pressure turbine. Thus the low-pressure turbines run on full load, and only the balance of the power required is drawn from the reservoir. At night, since the pumping load is constant, hand control suffices. The duplication of the low-pressure turbines has a considerable advantage apart from facilitating overhauling. Thus, on occasions when it is necessary to work overtime, the central generator would be driven by one low-pressure turbine—for this purpose one turbine is provided with a governor—the other turbine, on hand regulation, driving its pump all the time.

In line with the generator driven by the low-pressure turbines are shafts carrying crowned pulleys exactly similar to those on the generator. These shafts drive the high-pressure pumps creating the required head of 1050ft. During the idle hours the belts are changed over from the generator pulleys to the pump pulleys. Since the quantity of water delivered by each pump is relatively small, namely, 220 gallons per minute, it would have been quite impracticable to have run the pumps at a speed of 600 revolutions per minute, and therefore a gear drive had to be resorted to in order that the pumps themselves might be run at 3000 revolutions per minute. To isolate the gear-case and prevent any side pull interfering with the correct meshing of the gear wheels, flexible couplings are provided on each side of the gear-boxes.

The pumps deliver through 4in. pipes into a bus pipe immediately outside the power-house wall. This bus pipe is connected both to the 9in. high-pressure pipe leading up the hill to the reservoir and to the 6in. pipe for supplying the high-pressure turbine. This latter turbine is of the Pelton type, and under an effective head of 897ft. develops 230 horse-power.

Because of the length of the pipe line, precautions had to be taken against the water hammer effect when the turbine was shut down suddenly, as, for example, in the event of the load coming off. To this end Boving's patented system of combined needle and deflector regulation was adopted. On the load coming off, the deflector cuts into the jet of water issuing from the nozzle and throws the power off the wheel. The needle is then allowed to move slowly forward to reduce the jet to the size corresponding with the new load, the deflector meantime taking up its position immediately above the reduced jet. In this way waste of water takes place only during the few seconds of the regulating period. Rapidity of action is contributed by the deflector and economic control by the needle. The Pelton wheel runs at 1000 revolutions per minute, and is coupled direct to a 155-kilowatt generator. The whole electrical system is direct current, and the pressure adopted is 250 volts, the switchboard for distributing the energy being accommodated at the end of the machine room.

In Fig. 6 is shown one of the low-pressure turbines during the course of erection in its own pit. The bulk-head seen on the left was cast into the wall, which afterwards formed one of the sides of the water-tight chamber containing the belt pulleys. Fig. 8—page 184—is an interior view of the power-house taken from the switchboard end. The belts coming up from the low-pressure turbines and driving the central generator are clearly shown. On the right-hand side are seen one of the high-pressure pumps and the gear-box, through which the pump is driven. Fig. 9—also on page 184—is an interior view taken from the other end of the power-house, and shows the governor controlling one of the low-pressure turbines in the foreground, and the switchboard in the background. Fig. 7 shows the 230 horse-power Pelton wheel with its generator and governor. The size of this power unit may be contrasted with that of the low-pressure turbines, each of which has only half the horse-power of this small Pelton wheel.

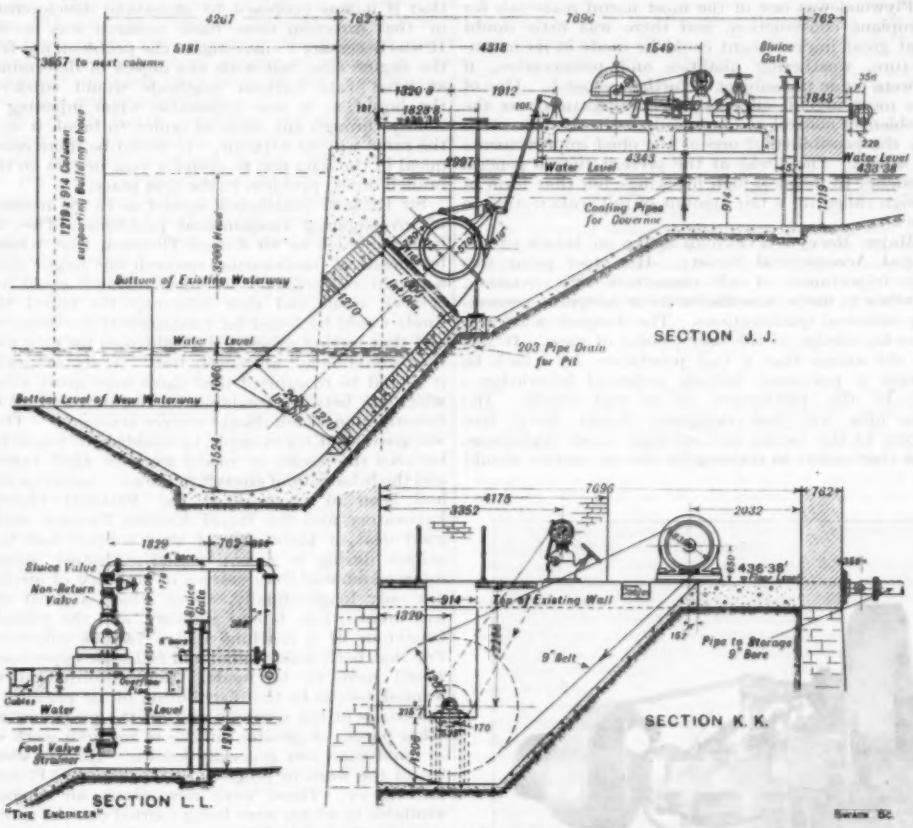


FIG. 5—SECTIONAL ELEVATIONS OF POWER HOUSE

Leaving the interior of the little power station, we come to the 9in. pipe through which the water is pumped to the reservoir and which brings the water down to the Pelton wheel. Fig. 2 shows this pipe line being laid in the trench up the hillside. Over the upper portion, where the head is less than 300ft., an ordinary slip joint was considered satisfactory, but, as seen in the engraving, for higher heads the pipes are flange-jointed. The faces of the flanges are machined, and rubber packing rings are provided to make the joints water-tight. The static pressure at the lower end amounts to 455 lb. per square inch. As the pipes are buried underground except for a small portion near the mill, and as the water is either flowing up or coming down through the pipe practically the whole time, no danger arising from frost is anticipated.

At the outlet from the surge tank an automatic butterfly valve is provided. If by any accident a burst should occur in the 9in. pipe this valve would be operated by the increase of velocity. The valve would be tripped and would slowly close under the control of a dashpot, thus stopping the waste of water and preventing any possibility of a wash-out occurring. The surge tank is 4ft. 6in. square, and in it a 12in. rectangular gauge has been incorporated through which the whole of the discharge from the pumps can be diverted by closing down the valve to the reservoir. In this way the efficiency of the pumps can be checked from time to time. The top of the surge tank has been covered in with expanded metal to provide against the possibility of stones being thrown in by children, which might work down the pipe and damage the Pelton wheel.

One of the biggest works in connection with the whole installation was the construction of the reservoir. The longest period of pumping is from mid-day on Saturday till Monday morning, *i.e.*, forty-two hours, and at their rated capacity the pumps will in that time deliver 1,108,800 gallons. During the working hours of any one day, if the Pelton wheel were kept continuously on full load, 546,750 gallons would be consumed in nine hours. Allowing that one hour of the remaining fifteen hours is lost each day in changing over and at meal times, the pumps could run for fourteen hours and replace 369,600 gallons, the deficit being 177,150 gallons per night. This shortage, with the five hours' draw-off on Saturday, would lead to a total deficit when the week's work was finished, of 1,189,500 gallons. It will thus be seen that the reservoir water used during the week would slightly exceed the quantity pumped into the reservoir. It must be noted, however, that this circumstance would only arise if the Pelton wheel were kept on full load during the whole of the working hours, a contingency that will not normally have to be faced.

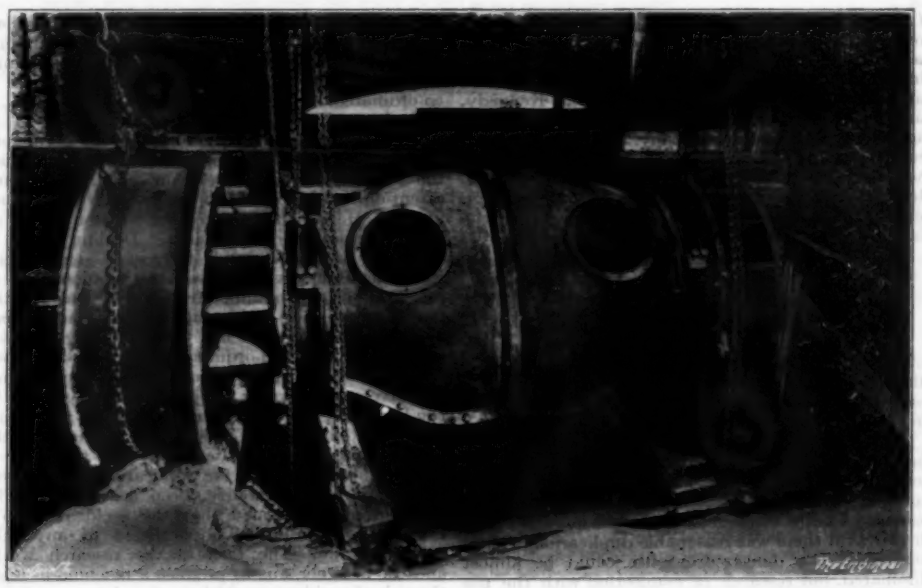


FIG. 6—ONE OF THE LOW-PRESSURE FRANCIS TURBINES IN ITS PIT

Theoretically, a reservoir capacity of slightly under 1,200,000 gallons would be adequate for the purposes of the scheme. A certain margin has, however, to be allowed to provide against the pumps being stopped to permit the overhaul of any part of the plant, and also because in times of exceptional drought it might not be possible to run the pumps at full capacity. It was therefore decided to enlarge the reservoir so as to provide a surplus storage capacity to carry over

from favourable to unfavourable weeks. A reservoir of 3¼ million gallons capacity was ultimately decided upon. A general view of this reservoir during construction is given in Fig. 10—page 184. The reservoir is 192ft. square by 15ft. 6in. deep. Because of the possibility of the ground not being water-tight, the bottom of the reservoir was formed as a 9in. slab of reinforced concrete laid directly on the solid ground. This slab contains a light mesh of steel reinforcement to provide against any upward stresses produced by changes of temperature or by hydrostatic pressure from the outside when the reservoir is empty. This meshing is shown clearly in Fig. 11—page 184.

The reservoir walls—Fig. 3—vary from 8in. thick at the top to 21in. at the bottom, and are heavily reinforced, the reinforcement being tied into the floor so that the walls can distribute their load on the cantilever principle. The taper of the walls was increased near the foot to provide against the bending moment which increases rapidly as the floor is approached. The tensile stress in the vertical rods of the wall was limited to 6½ tons per square inch, with a view to minimising the possibility of surface cracking taking place. A 1 : 2 : 4 mixture was used, and great care was exercised in the selection, grading and mixing of the constituent parts. During a recent test no leakage or sweating in any part of the reservoir was observed. This fact is particularly satisfactory in view of the very difficult conditions obtaining at the altitude of the reservoir during its construction.

The plant has now been in successful operation for several weeks. As has already been pointed out, the scheme was proposed by Boving and Co., Limited, who have acted as main contractors for the supply

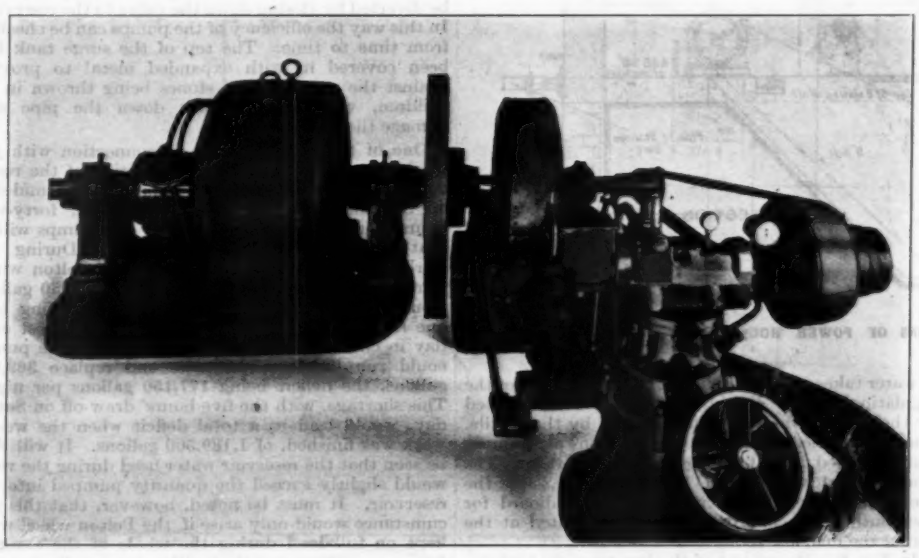


FIG. 7—PELTON WHEEL, GOVERNOR AND ELECTRIC GENERATOR

of the hydraulic equipment, including the turbines, governors, generators, pumps, gearing, pipes and valves. The generators were supplied to them by Bruce Peebles and Co., Limited, the pipes by Mechans, Limited, and the valves by Glenfield and Kennedy, Limited. The reservoir was designed in detail by the Considère Construction Company, Limited. Melville, Dundas and Whitson, Limited, were contractors for the construction work. Mr. J. Sharp, Wh. Sc., M.I. Mech. E., of Glasgow, acted as consulting engineer during the construction and erection of the plant.

Air Conference.

No. II.*

THE concluding session of the Conference was allocated to the discussion of the two papers on research by Major-General Bagnall Wild and Major Green respectively, and that of Major Scott on airships.

In opening the discussion Captain de Havilland said that safety was one of the first matters for consideration. As a result of the large amount of research work on the strength of aeroplane structures it was possible to build machines that would not fail in the air provided there was reasonable duplication of vital members. The danger from fire could be almost eliminated, but research in connection with the use of heavy oil should be continued, not only because its use would ensure safety from fire, but because the fuel costs would be considerably reduced. The question of single *versus* multi-engined machines was very important, and he agreed with Major Green that the single-engined type was in practice as reliable as the multi-engined machine. To make the latter really safe from forced descents the load would have to be decreased to an extent which would render the machine impossible for commercial requirements. In applying the results of wind tunnel tests on model wings to full scale work a reasonable degree of accuracy in prediction was now possible even with unusual wing forms. A recently designed machine had been flown with a loading of 15 lb. per square foot, and normal full load would be 17 lb. per square foot. The wing area of this machine was based entirely on model tests. He agreed with Major Green that metal would ultimately find its place in aeroplane construction, but it was too early to press for its more extended use.

Plywood was one of the most useful materials for aeroplane construction, and there was little doubt that great improvement could be made in its manufacture, weathering qualities and preservation, if it were made the subject of further research. One of the most urgent subjects for investigation was the problem of control at low speeds, as in that direction lay the possibility of one of the chief improvements in safety. There was at the present time a general tendency to develop high lift wings, but that form of design called for a fair amount of full scale testing in the air.

Major Mervyn O'Gorman spoke on behalf of the Royal Aeronautical Society. His chief point was the importance of all concerned with aviation, whether as users, manufacturers or designers, possessing technical qualifications. The designer must also have knowledge of the user's point of view. It was an old axiom that a bad purchaser—by which he meant a purchaser lacking technical knowledge—led to the production of a bad article. His own idea was that designers should have free access to the tactics and strategy of all operations, and that cadets in training for the air service should be given sufficient technical education to enable them to express their views on design from the military standpoint. The whole business of designing, manufacturing and operating machines must be co-ordinated.

Professor Bairstow quoted the opinion of the chairman of the Advisory Committee for Aeronautics in America that the countries which had produced the best aircraft were those in which the greatest attention had been paid to the research side of aeronautics. He was referring to Germany for airship and Great Britain for aeroplanes. Dealing with the question of model and full scale experiments, Professor Bairstow expressed the opinion that the information to be obtained from purely mathematical research would be more valuable than any experiments during the next few years. He agreed as to the need of more co-ordination. Progress had been hampered by the lack of contact between designers and research workers. Major Green suggested that the latter did not show their results in a form which could be applied by the designer. The truth was that the science of aeronautics was still too near to fundamental principles for application in that way. Something had, of course, been accomplished, but it could not be denied that the accident ratio in aeronautics was quite unparalleled in any other sphere of life. The task of the research worker and the designer was to produce a machine in which the risk of accident would be reduced to a minimum. Referring to airships, Professor Bairstow asserted that in spite of the disaster to R 38, it was now fairly common knowledge that a serviceable airship could be built in this country.

Professor W. E. Burstall discussed the co-operation of the universities in the research work on aircraft. Speaking for the Northern universities, he was able to say that they were quite sympathetic towards aeronautics, but they were hampered by lack of funds. Referring to engine problems, he thought that the work of Ricardo had brought the ordinary motor working with a carburetter to the limits of economy and practicability. General Bagnall Wild had referred to the question of injection—either solid or air injection. There was no doubt that air injection was a most efficient method of atomising and preparing the fuel for combustion, but it suffered from the defect that with an engine weighing only 2¼ lb. per brake horsepower, it was not very easy of application. On the other hand, the solid injection method had several inherent disadvantages. He could not help thinking that if it was proposed to undertake developments in that direction more basic research was needed. It was necessary to investigate the problem, not from the engine side, but with the object of determining at what rate various methods would subdivide the liquid, as it was impossible when injecting oil solidly through any form of orifice to break it up in the same way as with air. It would be more economical in the long run to spend a year or two on that branch of the problem in the first place.

Sir Richard Glazebrook agreed as to the necessity of investigating fundamental problems. They had been reminded by Sir Joseph Thomson that whereas by means of fundamental research one might create a revolution, ordinary technical research could only achieve small and slow reforms. He hoped that funds would be found for fundamental investigation, and that having selected the right men for this work they would be left absolutely free. At the same time it should be recognised that there were many things which lay between fundamental research and *ad hoc* investigation which should receive attention. There was great need, for example, to establish the connection between the results of model work in wind tunnels and the behaviour of aircraft in the air. Investigations had been in progress at the National Physical Laboratory and the Royal Aircraft Factory, and a good deal of knowledge of that subject had been gained during a recent period. Another subject for research was the question of stability of aircraft, not only longitudinally, about which a great deal was known, but lateral stability, and the probable behaviour of a machine under various conditions. For that both wind tunnel and full scale experiments would have to be made. More information was wanted, too, as to the distribution of air pressure on the wings of the machine and on the propellers and other parts. A greater volume of research work was in hand than was generally known. He had seen a list of the work in progress at the National Physical Laboratory. There were now seven air channels available in which were being carried out the general investigation of stability for complete models, tests of the behaviour of air screws, application of the strip theory to thick wings, the general theory of stresses in aeroplane and airship construction, and the elasticity of materials of construction. Good work was also being done at the Royal Aircraft factory. The real need at the present time was for the investigation of fundamental questions, such as the nature of fatigue fracture, the properties of alloy steel and the properties of aluminium alloys. For that kind of work the help of the universities could be obtained. Referring to airships, there was, he said, work which might be and should be done. It was said after the accident to the R 38 that the debt to Nature had now been paid. It should not have been necessary to pay that debt if research work had been undertaken in time, and, indeed, information was available before the disaster, had it been utilised to the full, which would have raised great doubts as to the safety of that airship. It was not utilised, for the information was avowedly incomplete and those responsible for the design of the R 38 declined to accept the results of air-channel experiments as being a sure guide. What was wanted was a connecting link between full scale and model research. It was not possible to obtain safety and the high performance called for in the R 38 without further work, although we could to-day build a safe commercial airship. He would press on the Government the need for undertaking experiments on the airships which were still available, as if they were destroyed the first thing necessary when a fresh start was made would be to build airships for the experimental work which could be carried out now.

Mr. A. Chorlton wanted increased concentration on methods of construction. There was a tendency to give too much attention to the gains which might be made on the thermodynamic side of the engine, although such gains could not exceed 10 per cent., rather than on other aspects of the engine problem. He was a firm believer in the light-weight engine, and an attack on the metallurgical side gave more hope of achievement than a thermodynamic investigation. Some of that work had been done at the National Physical Laboratory, and the Y model was one of the results. From his point of view, however, the work had been too academic, and he suggested that the Director of Research should obtain the co-operation of some of the great business firms and search for a lighter weight engine in a practical way from the metallurgical point of view.

Professor B. M. Jones said that the gap between theoretical and technical people, which was partially closed during the war, showed a tendency to reopen. It was essential that a proportion of the technical ability of the industry should be represented in people who had a personal experience of flying. The difficulty was to make it possible for those who were

* No. I appeared February 10th.

receiving technical training in aeronautics or technical training which could be applied to aeronautics to obtain the opportunity of learning to fly. He proposed that the Air Minister should consider a scheme for the formation of a small reserve made up of men coming from the universities or other institutions who had had theoretical training and admit them for a year or eighteen months into the Air Force. Much had been said in the course of the discussion about safety and regularity in commercial flying. Regularity meant flying in all weathers, but although there was an instrument available in the form of the turn indicator which would enable aviators to fly without danger in clouds, he was surprised to learn that none of the cross-Channel machines was fitted with it.

Mr. G. D. North supported the demand for the greater use of metal in construction. A machine could be built in metal to-day which would be 10 per cent. lighter than a wooden aeroplane and would cost very little more. He believed that by the greater use of high tensile steel, combined with light alloys, a structure weight of 25 per cent. was well within sight.

Mr. H. B. Pollen referred to the lack of novelty in aeroplane design. Caproni, the Italian constructor, had made an endeavour to get away from orthodox methods and it would be interesting to have a research into the type of machine suggested by his experiments. Reference had been made to the use of steel construction, but he would point out that it was not only expensive, but contained a great number of small parts riveted together which was a disadvantage. The ideal at which to aim was a combination of wood and steel. All the main structure, compression members and tie-rods should be made as lightly as possible in steel and other parts in wood. It would appear that money was to be allocated to investigate the use of helicopters, but he would suggest that it would be preferable to spend the sum available on engine research work to determine, among other things, the respective merits of air-cooled *versus* water-cooled engines. The present type of commercial machine was a military type with a limousine body, and nothing new had been attempted except the introduction of the slotted and high lift wings. International rules were required on the subject of landing speeds and factors of safety, as otherwise those countries imposing high factors of safety would be at a disadvantage in the commercial field.

Captain E. R. Hill insisted that the need of making the aeroplane a safer vehicle of transport was the most important question for those engaged in the industry. There was a tendency to obscure the accident risk by working it out to several places of decimals, but he would like to point out that if travelling on the London tube railways was as dangerous as travelling by air, about 300 people would be killed every day.

In concluding the discussion, Captain Guest referred to the difficulties under which the Controller of Civil Aviation had had to work during the past eighteen months. Pressure had been put on the Ministry to curtail its operations, and during a recent period it had been engaged in a life-and-death struggle to preserve its independent existence. The future of civil aviation depended on the endeavour meeting with success, as the older Services would destroy the Ministry root and branch if those associated with aviation did not fight to keep up their end. The cross-Channel services had been a flying but not a commercial success, and efforts should now be transferred to the development of Imperial communications. He was doing his utmost to preserve the *personnel* which had been employed on airship work by finding appointments elsewhere. On the subject of the disposal of the existing airships or their deletion, it had to be borne in mind that to try to start an experimental service with a long period subsidy would cost just as much as beginning *de novo* in better times. He recognised the importance of research work, realising that it was on the technical and scientific sides that progress depended. The suggestions which had emanated from the Conference would have the careful consideration of the Air Ministry.

EDUCATIONAL INTELLIGENCE.

THE Council of the University of Sheffield at its last meeting made the following appointments:—(1) Mr. Douglas Hay B.Sc. (London), A.M. Inst. C.E., to the Chair of Mining; and (2) Mr. A. J. Saxton, M.Sc. (Sheffield), to the post of Assistant Lecturer in Physics.

THE JOURNAL OF THE INSTITUTE OF METALS, VOL. XXVI.—The work done at the Birmingham meeting of the Institute of Metals occupies the greater portion of this volume, the twelve papers read at that meeting being printed in full with the discussions. But occupying a foremost place in the volume is the hitherto unpublished May Lecture by Professor Thomas Turner, in which the author points out that the casting of metals is not a science but an art, yet an art which is based upon scientific principles. He speaks sympathetically of the foundry worker, for "in the final operations, success or failure depends upon the skill, attention and devotion of the experienced workman, who as a result of years of training has acquired a knowledge which he is often unable to express in words, but which it is the desire of every true craftsman to impress upon the product which is the outcome of his labour." The final section of the volume is a comprehensive survey of papers recently published throughout the world, and dealing with the non-ferrous metals and related industries. This section has now reached such dimensions that it occupies nearly as many pages as the entire pre-war volume issued by the Institute.

Letters to the Editor.

(We do not hold ourselves responsible for the opinions of our correspondents.)

ECONOMY AND THE GAS TURBINE.

SIR,—Yesterday's issue of THE ENGINEER is noteworthy, in particular to the student of thermodynamics; in general, to the statistician and to the economist. For it contains, first, Mr. Hepburn's letter, a most illuminative commentary upon the gas turbine; secondly, the Electricity Commissioners' figures for fuel consumption in central power stations; and thirdly, an admirable leader upon power economy. I wish later to correlate the particular with the general: to consider the solution of a problem in thermodynamics as an economic asset; but first I should like to reply to Mr. Hepburn.

I owe Mr. Hepburn an apology. In my letter of January 27th I doubted the quantitative value of his suggestion, but since reading his letter in yesterday's issue, his argument has prevailed with me. If a kinetic compressor of the kind conceived by Mr. Hepburn can be made to work in practice, it seems that the solution of the gas turbine problem is near at hand.

The following comparative analyses of gas turbine cycles (heat absorption at constant pressure) working with the common rotary compressor and with the kinetic compressor are significant. For the sake of simplicity an "air standard" has been herewith adopted, the thermodynamic constants assumed being as follows:—

$$C_p = .24$$
$$C_v = .17$$
$$\gamma = 1.41$$

The expansion ratio is taken to be 10 and to be wholly sub-atmospheric. The temperature after expansion is taken at 773 deg. abs. This gives a value of 1510 deg. abs. for T_1, the initial temperature in the cycle. The work done per pound of gas, W, will be 177 T.U. (adiabatic expansion). The work of compression in the pump, w, will be 43 T.U. (isothermal compression). The heat put into the system, H, will be 293 T.U.

(*a*) *System with Rotary Compressor.*—Efficiency of turbine = .7. Efficiency of pump = .7. Then overall efficiency of the system, $E = (.7\,W - w/.7)/H = .215$.

(*b*) *System with Kinetic Compressor.*—As above, W = 177, w = 43, H = 293, and the efficiency of the turbine remains the same as in the above case, except in respect to residual velocity. Let the efficiency of the kinetic compression be .85; the T.U.'s required for the negative work then become $w/.85 = 50$ T.U. This leaves 127 T.U. for the turbine. Since the residual velocity is absorbed in the negative work, the efficiency of the turbine may be taken at .8. Thus $E = (.8\,(W - 50))/H = .347$. Therefore method (*b*) gives an increase in overall efficiency over method (*a*) of about 60 per cent. It is clear that in any kinetic compression system there must be a minimum loss in velocity between turbine and pump. Therefore, the sectional area of the cooler must be initially equal to that of the turbine exit and this area must decrease as the volume of the cooled gases decreases. Thus, if T_2 and T_3 be the absolute temperatures of the gases entering and leaving the cooler, the initial and final areas A_2 and A_3, then $A_2/A_3 = T_2/T_3$.

The velocity of the gases passing through the cooler will be

$$v_3 = 2\,g\,J\,50 = 3000 \text{ ft./sec.}$$

The delivery required for a 1000 brake horse-power turbine under these conditions is 3.87 lb. per second. This gives an exit area from turbine equal to inlet area to cooler of 62 square inches.

If T_2 be 288 deg. abs., the heat to be absorbed in the cooler becomes 1,620,000 T.U. per hour. Assuming a heat transference of 2000 T.U. per square foot per hour, 810 square feet of surface will be needed. With tubes of 1in. diameter this makes seventy-nine tubes 40ft. long to provide the required passage area and cooling surface. These figures are only meant to be indicative.

This brief analysis shows something of the conditions of Mr. Hepburn's thesis. Whether or no the direct absorption of the negative work by the residual kinetic energy of the gas is practically feasible, and, if so, by what means this end is to be achieved, I can venture no opinion. But the problem seems to be worthy of further inquiry.

The more general relation of the gas turbine problem to economy in power seems to be inadequately understood; even Mr. Hepburn refers to the Diesel engine, and the gas turbine seems to be conceived by many as a competitor with the gas engine.

I would reiterate with the utmost insistence that the internal combustion turbine is primarily a rival to the steam turbine. Although the steam turbine has a far lower efficiency than the gas engine, it is universally used for large powers, since there is a power limitation in all internal combustion piston engines.

I will state no figure for this limitation of power per cylinder. I know well that whatever figure I stated, this journal would be snowed under for weeks afterwards by letters from makers of such machines who have successfully exceeded the limit stated. I would be told that there is a gas engine in Timbuctoo with 2000 horse-power per cylinder, a Diesel engine in Nova Zembla with 3000 horse-power per cylinder, and so on. Still the fact remains that all internal combustion piston engines are limited as to power whilst the turbine is, for all practical purposes, unlimited as to power.

I repeat that the gas turbine competes essentially with the steam turbine.

If the figures of the Electricity Commissioners, published in yesterday's issue of this journal, be consulted it will be noted that of the total 5000 millions of units generated in this country, 28 millions, or .56 per cent., were generated by internal combustion engines. The best coal consumption quoted for the steam-driven stations is given as 1.78 lb. per unit generated, corresponding to an efficiency of 17.75 per cent. The average coal consumption for all sizes of stations is quoted at 3.32 lb.

Apart from the thesis discussed in the beginning of this letter, an efficiency of 30 per cent. should be obtained with the constant-pressure gas turbine, working within accepted limitations. If the efficiency of the gas producer be taken at 80 per cent., an overall efficiency of 24 per cent. is obtained corresponding to the 17.75 per cent. best efficiency quoted above.

From the tables published by the Commissioners it will be seen that the average consumption for power stations of over 50 million units is 2.71 lb. The recommendation of the Electricity Commissioners, I take it, is to reduce the present average consumption of 3.32 lb. to the 2.71 lb. value by centralising the stations. That is to say, to reduce the present consumption by 18 per cent.

If it were possible to replace the steam turbine plant of 17.75 per cent. efficiency with a gas turbine plant of 24 per cent. efficiency a proportional saving in fuel consumption would be effected of 26 per cent.

No sane man wishes to disparage the excellent and necessary work of the Electricity Commissioners, but even Commissions have to be paid for. If reference is made to the first annual report of the Electricity Commission and to the balance sheet therein, the net cost of the Commission for the year will be seen to have been a little over £40,000. To gain a reduction of 18 per cent. in present fuel consumption in the power stations of this country is well worth a paltry £40,000 a year. But to obtain a possible (or even greater?) reduction of 26 per cent. would be even better worth the money. Yet £40,000 spent in a research that would admittedly revolutionise power production is known only in the dreams of good scientists. In this country it is, alas, to the good bureaucrat alone (in spite of minatory axes) that such jolly dreams come true.

NORMAN DAVEY.

Ewell, February 11th.

SOME POINTS IN MANUFACTURING.

SIR,—Your correspondent, in the issue of THE ENGINEER for February 10th, Mr. H. T. Fowler, states the current views of the British motor manufacturer in saying that the Ford system of manufacture is not suitable for this country, owing to the limitations of the market at home.

This is, of course, true as far as it goes, but the fact remains that the market for British-made cars would have been very much greater had the greater number of British manufacturers made the type of car that most people in the world want, and left the high-priced luxury cars in the hands of the few. I venture to say that in the British Empire we have almost as big a natural potential market as has the United States, a market in which we have the natural advantages of sentiment and close business connections, and the artificial advantage in most cases of a preferential duty. I have personally seen appeals from all the Dominions and most of the Colonies for a good general service car of British manufacture. Instead of catering for this trade, the British manufacturer has contented himself with sitting down behind a high tariff barrier and building cars that few persons can afford. Seeing that the present Government have no settled policy regarding protection—and as a coalition of free traders and tariff reformers cannot well have one—and with a General Election in the offing, the position of three-quarters of the British motor trade is, to say the least, precarious. On the other hand, cheap transport is the life-blood of *all* the other industries, and no Government could long resist a sustained appeal to permit the free import of the type of vehicle that the British manufacturer, for the most part, does not deign to make.

However, I am in a position to traverse the statement about the failure of mass production as applied to motor cars. There was a *general* failure in the motor trade, but the firms who are best able to ride out the storm are those whose production costs have been reduced by just those methods described in the Ford article. These firms to-day are the ones who produce full-sized touring cars at the cheapest price, and are consequently doing a fairly healthy trade, under adverse world conditions at home and abroad. These firms are those who joined the ranks of motor car makers since the Armistice, equipped with a prolonged pre-war experience of economic forms of engineering in other fields. I refer to such well-known firms as Cubitts, Beardmore, Gwynnes, and Ruston and Hornsby, whose productions seem to have brought new life to a decadent industry. These firms have been accustomed to produce goods for export, and their sales policy admits no such limitation as Mr. Fowler appears to defend.

These, with about an equal number of pre-war automobile firms who have reformed their methods, and who are chiefly connected with commercial vehicles, share amongst them perhaps nine-tenths of the export trade; but now they have to fight their way against fierce American competition, whereas for ten years prior to the war the Empire market was a gift.

With these facts in mind, I cannot but applaud your decision to print articles dealing with modern production methods, in the hope that the economies to be effected, many of which are quite applicable to current British engineering, may be brought home to what is perhaps the most conservative body of opinion in any enlightened country.

C. H.

London, February 14th.

HOT AIR FOR COMBUSTION.

SIR,—In reference to article No. 23 on "Power Station Design," in your issue of February 10th, the following claims are made by the advocates of heating air for combustion purposes:—

(1) An efficient air heater is considered to be superior to an economiser from every point of view.

(2) The "Usco" air heater only occupies about one-sixth of the space of the usual economiser of smaller heat absorbent capacity.

(3) The heat absorbed and returned to the boiler by the "Usco" air heater results in a greater economy than would be obtained if the same amount of heat were returned by a water economiser.

(4) There is no complicated scraper gear associated with an air heater, for all the cleaning is done by means of steam jets.

In connection with these claims, which, in case (1), amount to a direct challenge to the whole economiser industry, I should like to point out that, however efficient an air heater may be considered to be, there are at least one or two considerations which would militate against the supplying of an air heater in preference to an economiser, and therefore it is hardly correct to state that an efficient air heater is superior to an economiser from every point of view.

In the first place, it is not generally realised that of the heat put into the air only a certain percentage is transmitted to the water in the boiler, this percentage being governed by the percentage efficiency of the boiler, whereas in connection with water heating the whole of the heat transmitted to the water is retained, *e.g.*, assuming a boiler with an efficiency of 70 per cent., for every 100 B.Th.U. put into the air the contents of the boiler would receive 70 only, whereas, on the other hand, for every 100 B.Th.U. put into the water by an economiser 100 B.Th.U. are retained, and therefore in this respect alone the air heater may be termed as being only 70 per cent. efficient as against a 100 per cent. efficiency for the water economiser.

The advocates of air heating naturally do not refer to this disadvantage of imparting heat, of which only, say, 70 per cent. can be utilised, and they also overlook the fact that if a heater is installed in lieu of an economiser there is no body of hot water to draw upon for peak loads; in other words, there is no thermal storage; the expansion strains on the boiler are not eliminated, but rather increased, and a deposit of scale takes place in a much

more expensive portion of the plant than would be the case were an economiser installed.

With regard to the space occupied, no mention is made of the space occupied by the fans and air ducts incidental to every hot air installation, to say nothing of the extra power required to force the air through a system of this nature, as compared with the almost negligible extra power required to force a very much smaller volume of water through an economiser.

Regarding the better combustion which is claimed when supplying hot air for the boiler furnaces, the fact must not be overlooked that trouble with clinkering and the overheating of firebars might very easily result in poor combustion and a serious loss instead of a gain. This is not a statement based on assumptions, but is the result of practical experience of engineers who have tried this system and scrapped it for this very reason.

In connection with the statement that no complicated scraper gear is associated with an air heater, we may state that at the present time there are many of the latest type of economiser working without scraper gear, arrangements having been made to blow the soot off the tubes by means of either compressed air or steam jets, and therefore the absence of scraper gear need not be put forward as an advantage of the air heater over the economiser.

The heat-transmitting portion of an air heating installation consists of either thin steel plates or thin steel tubes, which must necessarily have a very short life as compared with the life of an economiser, especially if, to the corrosive action of the gases, be added any condensation from the steam jets used for cleaning purposes.

Personally, I am of the opinion that there is probably room for all apparatus which promises economy, and it may transpire that there is room for both an air heater and an economiser, especially in view of the fact that if an air heater is supplying air to a furnace at a very much greater temperature there will be a possibility of an increased temperature leaving the boiler, with probably an increased margin available for heating both air and feed water.

I notice that on page 149 the statement is made that "heat returned to the boiler in the form of heated feed water does not improve the efficiency of the boiler itself," but I think you will agree that there is abundant proof to show that the hotter the feed water the more efficient is the boiler heating surface, because in the first place the boiler has a less duty to perform per unit of heating surface, and secondly, the actual surface is rendered more efficient owing to the great activity of the hot water as compared with cold.

One is quite willing to admit that there are advantages in the heating of the air by waste heat, but when the sweeping statement is made that air heating is better than water heating from every point of view, one feels bound to point out to your readers that somewhat extravagant claims are being put forward to the unfair detriment of an industry which has justified the whole of its claims over two or three decades, during which time air heating has been tried again and again and found wanting in some respect.

I might state that the economiser has almost justified itself, apart altogether from all question of economy, the question of thermal storage and the trapping of impurities in the feed water being a most important consideration in connection with water-tube boiler installations. GEORGE E. TANSLEY.

Wakefield, February 14th.

[The claims set forth for air heating were, as stated in the article, those of the makers of the "Usco" air heater, and several of the objections raised by Mr. Tansley were dealt with in our issue of December 30th.—ED. THE E.]

THE CO-ORDINATION OF RESEARCH.

SIR,—That the maintenance of research in almost every direction is important and even vitally essential to national safety and progress has been proclaimed over and over again as a proved fact during the stressful times of the war. Through all financial straits, and in peace and disarmament as well as under conditions of threatened war, therefore, the scientific power of the nation must be maintained. Further, the immediate or almost immediate products of research are urgently needed to assist in the revival of our industries and in maintaining at the highest pitch the efficiency of such armament as is still admissible. Indeed, the more narrowly armament is restricted, say, by a limitation of tonnage of ships, the more vitally important does it become that the scientific efficiency of design and material shall be kept at the highest possible level. Reduction of weight has always been a vital factor in naval construction, for example; but its importance must be further increased when the last resource—increasing the size and tonnage of the ship—is entirely eliminated. Research on matters of this kind, therefore, becomes more rather than less urgently important than formerly.

In a general way, the last report of the Department of Scientific and Industrial Research indicates a realisation of this aspect of the matter, and there can be no doubt that the so-called "Co-ordinating Research Boards" set up by that Department are already doing valuable work in co-ordinating, and in some instances stimulating, researches of importance from the point of view of the fighting services. The activities of these co-ordinating boards is undoubtedly of value, but could it not be carried very much further? There is something to be said for the carrying on of researches on similar lines, but from somewhat different points of view, in several laboratories at the same time; but when acute economy becomes necessary, is it not time to inquire whether for efficiency it would not be an advantage to co-ordinate not only existing and potential researches, but the laboratories and workers carrying them out? And would it not be possible to make such co-ordination cover not only researches of direct importance to the fighting services, but also those—really of equally national importance—which are of interest in a really fundamental way, to the most important industries of the country? What mainly stands in the way of such co-ordination at present seems to be a so-called political principle whose application is of extremely doubtful wisdom in regard to research. This is the idea that industry should not be subsidised, and that researches of industrial importance shall be paid for—in part at least—by the industry concerned. Too rigid an adherence to this principle has already lead to the scattering of much research work into inefficient and comparatively expensive fragments, under diverse guidance, often of doubtful quality, and it stands in the way of certain researches altogether. Work which, although admittedly of fundamental importance, makes no immediate appeal to any particular industrial group becomes shelved—it is regarded as "too industrial" to be taken up by the co-ordinating boards and as too abstruse for the research associations or other industrial bodies.

In the interests of efficiency and economy it is to be hoped that the Research Department and its co-ordinating boards will take a very wide view on such questions. Beyond this, however, lies the question of practical efficiency in the carrying out of researches. If the scope of the co-ordinating boards could be sufficiently widened, their activities might well lead to the concentration of a large amount of research in a few large, efficiently equipped and staffed laboratories. I do not wish to suggest the removal of research from the universities and similar educational institutions; research is the breath of life to them, and should be encouraged and helped in every way; but their capacity, both as to quantity and the nature and magnitude of the work itself, is distinctly limited—far too limited to meet the present needs of the country. What I have in mind are, rather, the various laboratories and research establishments of Government Departments. The Admiralty and the War Office have each their own establishments of this kind, while at the National Pnysical Laboratory there is the largest group of all. Would it not be possible to meet the requirements of economy and efficiency at the same time by an actual amalgamation of several of these establishments? This might be done by concentrating all these services at the National Physical Laboratory, perhaps under a new and wider title, such as "The National Laboratory" or even the "Royal National Laboratory."

There is much to be said for this particular solution, but in any case there would be an immediate and considerable saving in overhead charges, and for many purposes an important saving in the duplication of buildings and equipment. There would be no need to diminish the actual staff of scientific investigators, since considerable savings would be effected in other ways, and the range of urgent problems which could be attacked would be appreciably widened. It would seem that there is here the possibility of effecting both economy and increased efficiency of output by carrying the process of co-ordination to its logical conclusion.

February 7th. RESEARCHER.

LOCOMOTIVES WITH FOUR EXCENTRICS.

SIR,—In the matter of the Verpilleux steam-tender locomotives I have to thank your correspondent Mr. Bushell for his reference to your issues of February, 1865. The illustration you give is either that of the first engine, built in 1844, with its steam storage chamber removed, or that of the second engine, built without a steam storage chamber. The chamber was 2 m. long, semi-circular in shape, with spherical-shaped ends, and was fixed to the boiler midway between the vertical steam domes. Like all such figure 8 constructions in locomotive boiler work, there was a "breathing movement" at the joints and consequent troubles from leakage. In a communication from M. Achard, of Belfort, I have it confirmed that in French histories of the locomotive the year 1844 is given as that in which the first Verpilleux steam-tender locomotive was built.

My desire for fuller particulars of these locomotives was prompted by a statement that the engine under the boiler was reversed by the usual four-excentric reversing gear, while the engine under the tender reversed automatically, that engine being fitted with two loose excentrics only. This latter arrangement is interesting historically as an anticipation of the automatic loose excentric reversing gear fitted by the late F. W. Webb to the low-pressure cylinders of his later constructions of three cylinder compound locomotives.

Your correspondent, Mr. Forward, in his comparison of the Forrester and Hawthorn four-excentric gears, ignores entirely the drawing and especially the description you gave of the former gear in your issue of March 2nd, 1883. In ignoring the latter he is undoubtedly justified, and it was the gear as described I characterised as a crude contrivance. No locomotive was ever built with such a gear. If, however, the drawing is carefully examined it is not difficult to arrive at the true construction of the gear.

The excentric rods were made with plain gabs provided with guards which rested on small excentrics formed on the reversing shaft. This latter was operated through an angle of 180 deg. by a toothed sector and pinion connected to a reversing handle on the footplate, the handle having three positions in which it could be fixed, viz., forward, backward, and out of gear. The valve-setting handles, one for each valve, were always fixed in their middle positions during the working of the engine, and the rods connecting them to their respective levers on the valve shafts had slots at their ends slightly longer than the movement of the pins in the levers. This construction is clearly indicated on the drawing and completely differentiates the gear from that of Hawthorn introduced a year later.

As an indication of the value to be placed upon the description published in 1883 I would mention the fact that the same writer in your issue of October 31st, 1879, stated that "No. 6, Experiment, of the Stockton and Darlington Railway, was built by the Stephensons. It had a return flue, its cylinders were placed horizontally, half in the boiler and fastened to the flue; the connection between the piston-rods and the crank pins outside of its wheels was made by means of levers; it was on four wheels." As a matter of fact the cylinders were placed vertically on top of the boiler and fastened to the boiler shell. Twin Sisters and the two engines built in 1827 for the St. Etienne and Andrezeaux Railway were the first engines to have their cylinders placed entirely outside the boiler by Stephenson and Co. Stockton No. 5 was the first by any builder. JAS. DUNLOP.

Glasgow, February 11th.

ANGLE-COMPOUND AIR COMPRESSOR AT A COLLIERY.

SIR,—With reference to the article in the issue of your paper for January 27th, illustrating and describing an American compressor of special design, one would think that with all the unemployment there is in England the design should present very special points of advantage to justify the placing of the order abroad. Something is said about even turning, but is the degree of even turning appreciably better than an ordinary vertical compressor with cranks at right angles and a fly-wheel; and, even if it were so, is the even turning a matter of such moment for a compressor?

The advantage can hardly lie in the space occupied, for the arrangement appears to be specially designed to occupy a maximum of space, both horizontally, vertically, and transversely. It would be interesting to know the space occupied and the size of the foundation block, which must be enormous for a 2000 cubic feet compressor. But is it a 2000 cubic feet compressor? The piston displacement is given as 2020 cubic feet. What was the actual quantity of free air compressed and delivered? The American compressor makers are great at swept volume, but one seldom hears of their compressors being tested. Is it fair to expect English compressor makers to quote on the quantity of air actually delivered, including an expensive test, and then go to the States and buy a compressor on swept volume and not require a test? Apparently no test was made in the case of this compressor, at any rate no results of such test are given; not even the delivery air pressure is stated. It would certainly be interesting to know how the efficiency of this novel design of compressor compares with first-class English makes of compressor, and what is the power required to operate it at no-load. With four cylinders where two would ordinarily be used and the low-pressure lines horizontal, the power which the motor will need to exert to run the compressor at full speed unloaded must be considerable, affecting the efficiency at all loads. The concentration of the work of the first and second-stage cylinders on the same crank pin I do not regard as a good feature.

Altogether, there does not seem to be much reason for purchasing compressors of this design in America, unless it was on delivery; and, if so, it would be interesting to know whether the delivery quoted was adhered to. CIVIS.

London, February 7th.

LIQUID PISTON PRIME MOVERS.

SIR,—A week or so back you accorded me space to suggest that the liquid piston internal combustion pump and turbine combination might be taken seriously as a means of fuel conservation. Since writing that letter there comes to my notice an inquiry from a foreign seat of education for such a plant which is not without interest; but further to that, there is also a significance, I think, in the figures quoted by the Electricity Commissioners in your issue of the 10th inst.

According to the table shown, the average consumption is 3.32 lb. per unit of current. In ordinary liquid piston pump practice 1.06 lb. per pump horse-power hour was attained many years back; more recent practice gives a consumption of under 1 lb. per pump horse-power hour. It should therefore be a simple matter for those interested in the construction and operation of turbo-electrical plant to "reverse the flow" and express such a consumption in terms of electrical units after making all the allowances for losses that experience dictates, and such a calculation would settle the efficiency as compared to usual station practice and as vouched for in the Commissioners' analyses. I am not personally sufficiently acquainted with modern turbine and generator sets to venture more than a mild opinion that I think the results will be found to be in favour of the pump and turbine combination, with considerable reductions in upkeep, and, of course, lubrication charges. S. P. CHRISTIE.

Bawtry, Yorks, February 13th.

MOND GAS PRODUCERS.

SIR,—In your report of the discussion on Messrs. Denny and Knibbs' paper at the recent meeting of the Institution of Mechanical Engineers in Manchester you attribute to me the statement that results obtained from Mond gas plant at Sheepbridge Collieries were better than those given in the paper. Your reporter has misunderstood me. What I said was that results obtained from many other Mond plants—and I named one or two—were better than those given in the paper. I would thank you if you will kindly correct this. The statement as it stands in your report is obviously inaccurate.

Manchester, February 10th. T. ROLAND WOLLASTON.

TRAIN SPEED IN 1921.

SIR,—Thank you for inserting my letter regarding the 12.25 p.m. non-stop train from Newton Abbot to Paddington. Relative to your comment, may I point out that this train *did* run in 1921; up till October it was timed to reach Paddington at 4.5 p.m., this being evidently the timing you referred to. Since October, 1921, it has been due at 3.50 p.m.—the time you give—when the best West Country trains were accelerated by a quarter of an hour. O. R. WALKEY.

February 11th.

[We thank Mr. Walkey for his correction.—ED. THE E.]

THE PANAMA CANAL SLIDES.

SIR,—In his reply to Mr. Harry Bates' question on the Panama Canal slides, Professor Stuart states that perhaps a century of dredging will be necessary before equilibrium is finally established in the banks on each side of the canal at Culebra.

If it takes all that time, and the enormous outlay incurred in dredging, is not the canal a failure from an engineering point of view? D. M. M.

February 13th.

WATER POWER IN JUGO SLAVIA.

THE Commercial Secretary to the British Legation at Belgrade reports that the Zágráb journal *Agramer Tagblatt* published an article concerning the formation of a syndicate for the development of hydro-electric power schemes which would be worked in collaboration with the S.H.S. State Government. This syndicate for the study of the water-power of the Bosna and Drina was formed at Vinkovci on November 6th, and the first thing agreed upon was the erection near Modric of a water-power station of 8000 horse-power capacity, and the construction of another station on the lower Drina, between Koviljaca and Janje, of 29,000 horse-power. The projected power stations are intended to provide current for Posavina, Podrinje, Slavonia, Syrmia, Backa, Djakovstina and Osijek, and it is proposed that they should be connected with the great overland electrical system which the State contemplates. There is also the intention to connect these systems, viâ Zágráb, with the power system of Fala, so that the project of the central Government to provide an organised network of electric power lines in an east and west direction and in a thoroughly practical manner could be accomplished without great delay. It is specially emphasised that these undertakings are assured of the co-operation of the State, so that the participation of foreign capital would only be permitted if native capital were insufficient, a contingency which it is considered the richness of the districts interested would seem to render unlikely.

A Seven-Day Journal.

Postponement of Empire Exhibition.

THE decision to defer the British Empire Exhibition, which it was intended to hold next year, until 1924 was not unexpected. The buildings, which are estimated to cost £1,500,000, could scarcely have been completed in time for the opening a year hence, as the first turf was only cut at Wembley Park a few days ago. It will be necessary, indeed, to employ some thousands of men to be ready for an exhibition in 1924. Apart from the risk of uncompleted buildings, representations have been made by exhibitors asking for a postponement. The Indian Government, which took the initiative in the matter, pressed for more time if an adequate display of the resources of India was to be made, and it is understood that all the Dominion Governments have given their assent to the postponement.

Composition of the Atom.

AN audience which packed the hall of the "Mechanicals" and tended to overflow, was attracted by Sir Ernest Rutherford's lecture to members of the Chemical Society on the fascinating subject of the artificial disintegration of the atom. His work in this field promises to yield some remarkable results, and it is possible we are on the threshold of discoveries which will furnish grounds for a new theory of the constitution of matter. It now appears that what the physicist of the last generation regarded as simple elements are highly complex structures. If the conception of the constitution of the atom which is based on recent investigation should be confirmed by subsequent work, new sources of energy of high potential value may be opened up, and Sir Ernest's experiments lead him to think that something akin to transmutation of the elements is at least within the bounds of possibility. His mental picture of the helium nuclei and the hydrogen satellites in nitrogen and the disintegration of the atom which can be effected by means of bombardment with alpha particles is an arresting chapter in modern physics. The scientific world, half convinced and half sceptical of the new ideas, is awaiting with some impatience the next instalment of the new story of the mighty atom.

Railways and Road Transport.

THE fact that the railways have shown their willingness to place the question of the rates they would charge for road transport under the jurisdiction of the Railway Rates Tribunal, and have undertaken not to build the lorries for road services but to place orders with the motor manufacturing industry, has not placated the opposition. The opponents of the grant of powers to the railway companies to enter the road transport arena are headed by the Federation of British Industries. It is argued that the readiness with which the railway companies are sacrificing the right to fix rates and build road vehicles in their own workshops is fresh evidence of a sinister intention to remove the increasing pressure of competition which is being felt from independent road contractors. The attitude of traders is that this competition can and should be met, not by the railways catering for road traffic, but by an improvement in the economy and efficiency of railway operation. The argument of the railway managements is that, as a considerable percentage of traffic which has been diverted from rail to road will always be carried by road because this method of transport is cheaper and more convenient, the railway companies can only recover it by themselves entering the road transport business. In addition to the West Scottish group, the Caledonian, Glasgow and South-Western and Highland railway companies are applying for a provisional order empowering them to provide and use road vehicles under the same conditions as the West Scottish group. The North-Western group, in accordance with English practice, is promoting a Bill.

Southern Railways Electrification.

IT is understood that difficulties have arisen between the partners of the proposed Southern group of railways on the subject of electrification. The Brighton electric lines are the outstanding example in Great Britain of the single-phase alternating system, whereas the London and South-Western Railway is operating its electric routes on the direct-current method, and the scheme which has been prepared for the South-Eastern and Chatham Railway, the other partner in the group, also specifies the use of direct current. The difficulty was, of course, foreseen when the Committee of the Ministry of Transport dealt with the question of electrification some time since, and it will be recalled that after mature consideration it was decided to leave the Brighton company to continue the conversion of its lines to electric traction in the state of splendid isolation which must be associated with the use of the single-phase system. It is possible that the new Committee, which is now sitting under the chairmanship of Sir Philip Nash, may reconsider the whole question, and it is reported that the plans of the Brighton company are in abeyance. The suggestion that the company may be asked to put its electrical equipment into line with that of other British companies may be dismissed. The cost of a change over would be too prohibitive to contemplate.

German Aircraft Industry.

A STATEMENT which has emanated from Berlin reminds us that the prohibition under the Peace Treaty of the manufacture of aeroplanes and air material by Germany for her own use will cease to be effective after May 5th. This is not quite correct; it is true that the work of the Inter-Allied Air Commission will finish on the date named, but it will be open to the Allied Governments to make such regulations as they may think fit in connection with aircraft manufacture in Germany, and to appoint an organisation to see that the regulations are observed. The German Government has agreed that it will be bound by regulations which may be imposed to differentiate between military and civil machines, and it may be taken for granted that the situation will be closely watched, and that as far as is possible, although the task will not be an easy one, Germany will be prevented from building up a large war fleet under the guise of civil aviation developments.

The White Star Liner Homeric.

ON Saturday last, at the invitation of the White Star Company, a numerous party visited Southampton by special train from London to inspect the Homeric, the latest addition to its fleet, which was due to sail on Wednesday, the 15th inst., on her first voyage to the United States under the White Star flag. The vessel, which was, of course, built in Germany, is the largest twin-screw steamship yet constructed. She has a length of 775ft. and a beam of 83ft., her gross tonnage being 35,000. Her propelling machinery consists of two sets of four-cylinder triple-expansion engines working at a steam pressure of 210 lb. per square inch. Her horse-power was not divulged, but her sea speed is, so we understand, to be between 19 and 20 knots. There is passenger accommodation for 2766 persons, made up of 529 first-class, 487 second-class and 1750 third-class. A feature of the first-class arrangements is that the majority of the cabins are only fitted with a single berth. In the third-class, too, there are two, four and six-berth cabins. The Homeric is not the largest ship in the White Star fleet, being 20,000 tons smaller than the Majestic, which, when completed, will be the largest liner which has yet been put in service. The advent of this ship will make the question of graving dock accommodation a somewhat urgent one, and it is satisfactory to learn that negotiations are now in progress between the London and South-Western Railway and the Government for the acquisition for use at Southampton of the huge floating dock which has been taken over from Germany by the Admiralty. A hitch has arisen, but it is hoped that, by the time the Majestic is completed, the floating dock, which is big enough to take the great liner, will be on her new station.

Tempering and Brittleness in Steel.

ONE of the defects of the chrome-nickel steel alloys—even that which, on account of its excellent mechanical properties, has come into fairly general use for motor car and aircraft work—is the tendency to brittleness after tempering. This can be corrected by quenching from the tempering heat in either oil or water, but this in turn may cause distortion of the material and involve a cold straightening operation, with possible effects on the mechanical properties. To provide a remedy for this condition of affairs, a research has been carried out in the Armstrong-Whitworth laboratories at Openshaw, and the result is claimed to be a new alloy which has even higher mechanical properties than the ordinary chrome-nickel alloys, and is not liable to tempering brittleness and does not require any special treatment.

Carbon Monoxide in Coal Gas.

IN his statement at the meeting of the South Metropolitan Gas Company on Wednesday, Dr. Charles Carpenter referred to the much-debated question of the percentage of the carbon monoxide present in coal gas. It is understood that the percentage of this gas which is contained in that supplied from the South Metropolitan mains is lower than in the gas supplied by many other companies, but taking this fact into consideration it is gratifying to learn that throughout the area served by the South Metropolitan Company there has not been a fatal accident due to gas poisoning for over twenty years. The sale of gas by the standard of therms, in place of a quantity standard, was, Dr. Carpenter explained, fairer to the consumer, and it was a system which had come to stay. He had also something of interest to tell shareholders in connection with the coal strike, during which the fuel stocks of the company had been drawn upon for public requirements outside the call from the gas industry. Complaints were rife, he added, that the price of gas was excessive, but it ought to be obvious that the selling price of gas did not respond immediately to changes in the cost of manufacture.

Post Office and Pneumatic Tubes.

IF the sanction of Parliament is obtained, the General Post Office will purchase the entire rights of the Pneumatic Dispatch Company and associated interests. It was as long since as 1863 that the first pneumatic tube was constructed for the purpose of conveying parcels from the General Post Office to Euston Goods Station by small cars driven by pneumatic pressure at a speed of 30 to 40 miles an hour. The tube measured 4ft. in height and 4½ft. in width, and the cars fitted the tunnel to within an inch all round, the space between being sealed by a rubber flange. The company was unsuccessful, and was struck eventually off the register. The great difficulty in pneumatic propulsion was keeping the tube air-tight, and after the original power had been increased six times the scheme was abandoned. It is an extraordinary fact that this tube, for which John Aird was the contractor, was practically forgotten, and it was not until the 'nineties that an attempt was made by a new company to revive the scheme and operate it by electric power. If it is acquired by the Post Office it will only be used as a conduit for telegraph and telephone cables.

Oil in Waterways.

ONE of the questions which came up for discussion at the annual meeting of the Dock and Harbour Authorities' Association on Wednesday was that of the methods to be adopted in dealing with the discharge of oil into dock and the approach channels thereto of ships carrying oil as cargo or employing it as fuel. The great increase in the use of oil fuel for raising steam in shipyards has greatly accentuated this difficulty, and although dock authorities are willing to co-operate in measures for dealing with the evil, they naturally decline to accept the full responsibility of providing reservoirs in docks and river channels. The big dock authorities, including London, Liverpool, Glasgow, and doubtless Southampton, will, wherever possible, undertake this task, and shipowners have fallen in with the suggestion that no legal obligation shall be placed upon port authorities to provide barges or other receptacles. Lord Devonport, who presided at the meeting of the Association at which he announced the compromise which had been reached, paid testimony to the assistance in settling points of difference which had been given by Mr. Hipwood, the head of the Marine Department of the Board of Trade.

Criticism of Railways Act.

THE negotiations which are in progress for the amalgamation of the railways constituting the various groups have brought out some difficulties which, although they should have been foreseen, were not fully realised by the framers of the Railways Act. In addressing the stockholders of the Brighton Railway Company this week, Mr. C. C. Macrae, the chairman of the company, gave it as his considered opinion that in the interests both of the railways and the public it would have been preferable if managements had been left unfettered by the provisions of the Act. Had there been no legislation, Mr. Macrae assumes that the economic condition of the railway industry would have made it desirable to arrange for a pooling of receipts and expenses with other lines. Such a pool could have been arranged without any great difficulty, but when it came to the fusion of capital of the companies forming the Southern Group, the problem was very complicated, and a state of stagnation with regard to development had been reached. Mr. Macrae believes—and his opinions are known to be shared by many other people—that considerable modifications of the Railways Act will have to be effected. One valuable amendment would, it is suggested, be to make the provisions as to fusion of capital permissive instead of compulsory.

Reduction of Japanese Armaments.

REPORTS just to hand indicate that as a result of the decision to reduce armaments, about 60,000 workers, including men employed at naval and military establishments, are to be discharged. The number of hands on the pay roll of the Japanese Imperial Dockyards is about 80,000, but it is hoped to find employment for a considerable percentage of them for some years in the breaking up of the warships, which are to be scrapped under the Washington agreement, and in the building of auxiliary vessels which are authorised by the naval pact.

Still Engine Developments.

No. I.

THE Still engine has been referred to in our pages on more than one occasion, notably when the paper describing this engine was read by Mr. Frank D. Acland, before the Royal Society of Arts, on May 26th, 1919,* and later when Mr. William Denny read his paper on "Comparative Trials of 'Still' and 'Sulzer' Engines," at the Liverpool Conference of the Institution of Naval Architects, in July, 1920.† Development work has been continuous both by the Still Engine Company, of 7, Princes-street, Westminster, which has dealt not only with the marine problem, but also with the wider applications of the Still principle; and its licencee, Scott's Shipbuilding and Engineering Company, Limited, of Greenock, which has specially devoted its attention to the perfecting of the slow-speed marine type of engine. Very exhaustive tests have been made with Messrs. Scott's experimental unit, both as regards details of construction and engine performance with various fuels under differing load conditions. Successful endurance trials have also been run.

Among the most important of the tests carried out on this engine, are those embodied in a report by Captain H. Riall Sankey, R.E. (retired), the full text of which we reproduce at the end of this article. The fundamental principle upon which the Still engine operates is shown diagrammatically in Fig. 9. The engine may well be described as a combined internal-combustion and steam engine, in which the heat of the products of combustion is recovered and converted into power through the agency of steam, this operation taking place in the combustion cylinder, the feed-water heater and the regenerator.

Another important point is that in the Still engine steam is utilised for cooling the piston, and as a certain amount of superheat is added to the steam during that process, the efficiency of the steam cycle is thereby improved. Compared with the ordinary type of Diesel oil engine, whether of the two-cycle or four-cycle type, the Still engine possesses a marked advantage, in that the power on the steam side may be largely augmented at starting, or when extra power is needed, by burning oil in the regenerator. Thus, during the starting period steam replaces compressed air for starting and manœuvring, and when running on load the steam generated from the heat of the exhaust gases is continuously used in the cylinders for producing power thereby achieving a marked economy in fuel.

From a full and able paper read by Mr. Archibald Rennie of Messrs. Scott's before the Institution of Engineers and Shipbuilders in Scotland, on Tuesday last, we are able to give in what follows some particulars of the Scott-Still experimental unit, and from that paper, too, we reproduce a general arrangement and other drawings of this engine. In a later article we hope to give further particulars of the engine details, such as valves and valve operating gear, and some of the special tests which have been carried out.

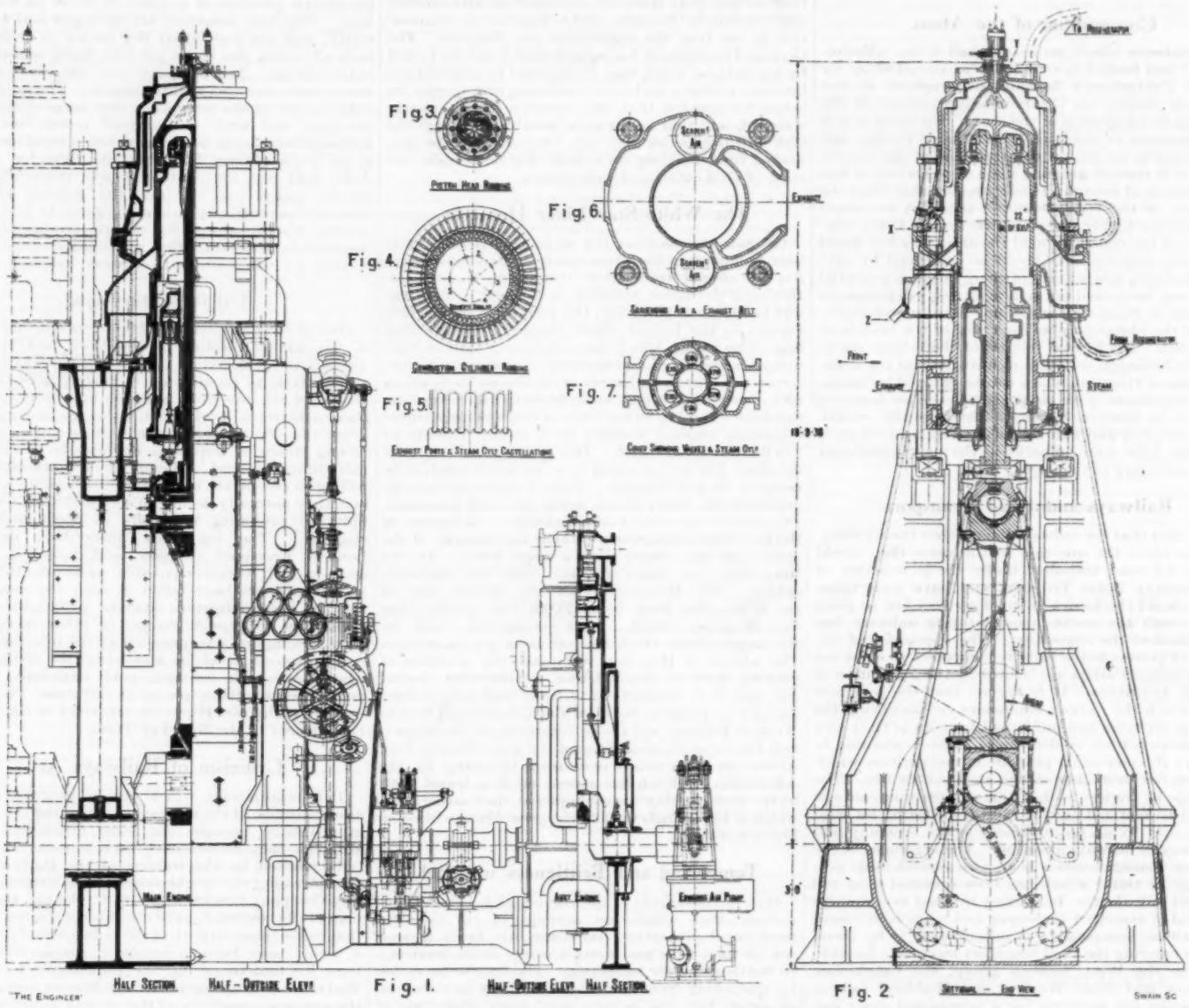
It appears from what Mr. Rennie says that, in considering the construction of a full-sized experimental unit for marine purposes, it was decided—see Figs. 1 and 2—that the engine should be of such dimensions as would cover a range of power varying from about 700 to 7000 brake horse-power, with single or twin screws and a reasonable number of cylinders. Consideration of revolutions, mean effective pressure, and other factors ultimately resulted in the choice of a cylinder of 22in. diameter and 36in. stroke being adopted as most suitable. Such an engine running at a speed of 120 revolutions per minute was estimated to give a normal brake horse-power of 350 in one cylinder at maximum efficiency and an overload of about 400 brake horse-power.

The crank shaft and bed-plate were designed so as to be suitable for six cylinders of this size in line. As, however, it was considered desirable to work the experimental engine on the compound principle on its steam side, so that its working condition might approximate as closely as possible to those which will obtain in a multi-cylinder engine on board ship, a small independent single-acting high-pressure steam engine with a cylinder of 14in. diameter and 22in. stroke was also constructed and coupled direct to the main engine crank shaft—Fig. 1. The cranks of the two cylinders are arranged at the same angle relative to the dead centres so that the pistons move up and down together. By this arrangement the steam side of the main or combustion cylinder which forms the low-pressure stage is ready to take steam just as the high-pressure cylinder begins to exhaust. The steam side of the main cylinder is 180 deg. of crank angle behind the oil side, so that the engine is double acting in its operation, with this limitation, however, that the power developed on the steam side is considerably less than that developed on the oil side.

The general arrangement of the engine and also some details of design are shown in Figs. 1 to 8. The columns are A-shaped, looking in a fore and aft direction, and are, in fact, simple front and back columns cast together. The guides are of the double slipper type, but split, and have one half carried by each column. This admits of the adoption of a special design of crosshead to be referred to later, and gives ready access to the engine both front and back. It also allows of the easy removal of the steam cylinder cover when desired. The spaces between the columns front and back and between the legs of each column are closed with portable doors. The combustion cylinder, which in its completed state may be said to consist of three parts, namely the working liner, the outer mantle, and the scavenging and exhaust belt is supported from the columns by four distance pieces, through which large steel bolts are passed, having their upper ends secured to the mantle and their lower ends let into and secured to the upper part of the columns. These bolts take the combustion load and transmit it through the columns to the bed-plate.

The steam and water jacket joints between the liner and mantle are made on the conical face and stuffing box shown at X and Y in Fig. 2. It will be seen that the working liner by this arrangement is secured at the bottom of its length, and is free within the mantle to adjust itself to changing temperatures. The mantle and belt are also free to adjust themselves independently of the liner. The liner itself is only $\frac{1}{2}$in. thick in the body. It is ribbed vertically and its upper half is fitted with steel shrouds shrunk on, to give the necessary strength to resist the bursting pressure due to combustion. Incidentally, these shrouds assist the convection currents within the jacket to a considerable extent.

A sectional plan of the liner is shown in Fig. 4. An important point in the design of the liner, and also



FIGS. 1 TO 7—SECTIONAL ELEVATIONS AND DETAILS OF THE SCOTT-STILL EXPERIMENTAL ENGINE

* See THE ENGINEER, May 30th, 1919.
† See THE ENGINEER, July 23rd, 1920.

of the piston head, is that examination of all the surfaces can be made, there being no hidden internal spaces. The combustion exhaust ports in the lower end of the liner are of special hooded form, and should be noted for the completeness with which they are water-cooled. The main idea underlying the design of the Still engine liner is the reduction of the temperature differences and consequent heat stresses between its inner and outer walls, to the lowest possible minimum, and the provision of ample surface for the rapid transfer of heat to the jacket water. The whole combustion load is taken by the breech end of the liner, and transmitted through the conical joint to the large steel bolts. There is no cylinder cover on the engine in the sense in which a cover is understood in oil engine practice. The cover shown fitted to the mantle takes the steam pressure only, and was provided to facilitate inspection of the water jacket space. No use has been found for it in this connection, however, and it is proposed to dispense with it in future construction.

The steam cylinder is supported from the columns quite independently of the combustion cylinder and has complete freedom for expansion. The cover is of deep formation, and is projected well into the cylinder, leaving only a small annulus with sufficient clearance for the piston skirt. The steam and exhaust valves, of which there are two and four respectively, of simple piston type are carried well on to the cover head, to reduce the steam clearance volume to a minimum, and are directly connected to their operators bolted on to the cover flange—see Fig. 1. Although described separately, the combustion and steam cylinders are component parts of a whole, with a common piston, and where the barrels of the cylinders meet they are formed with a series of fingers, which mesh with each other and overlap for about 1in., thereby providing ample guiding surface for the piston rings as they pass from one cylinder to the other—see Fig. 1. Oil for piston lubrication is introduced into the cylinder at three points in its circumference.

The piston is made in two parts. The skirt calls for no remark, but the head is spirally ribbed internally as shown in Fig. 3, to guide the flow of steam over the crown in as long a path as is reasonably possible. At the same time this formation provides the piston with some degree of flexibility and allows it to adjust itself to temperature conditions without danger of fracturing the ribs. The piston-rod is deeply embedded in the piston head with spigot and flange, and the attachment of the two is made by studs and nuts. The piston head is pierced by six holes for the guidance of the steam to the piston head, and is enlarged in diameter at this part to maintain its strength. These holes, acting in conjunction with the steam valves and ports, convey the steam during the admission period, into the cylinder by way of the ribbed space on the underside of the piston head, heating the steam and cooling the head, to the manifest advantage of both.

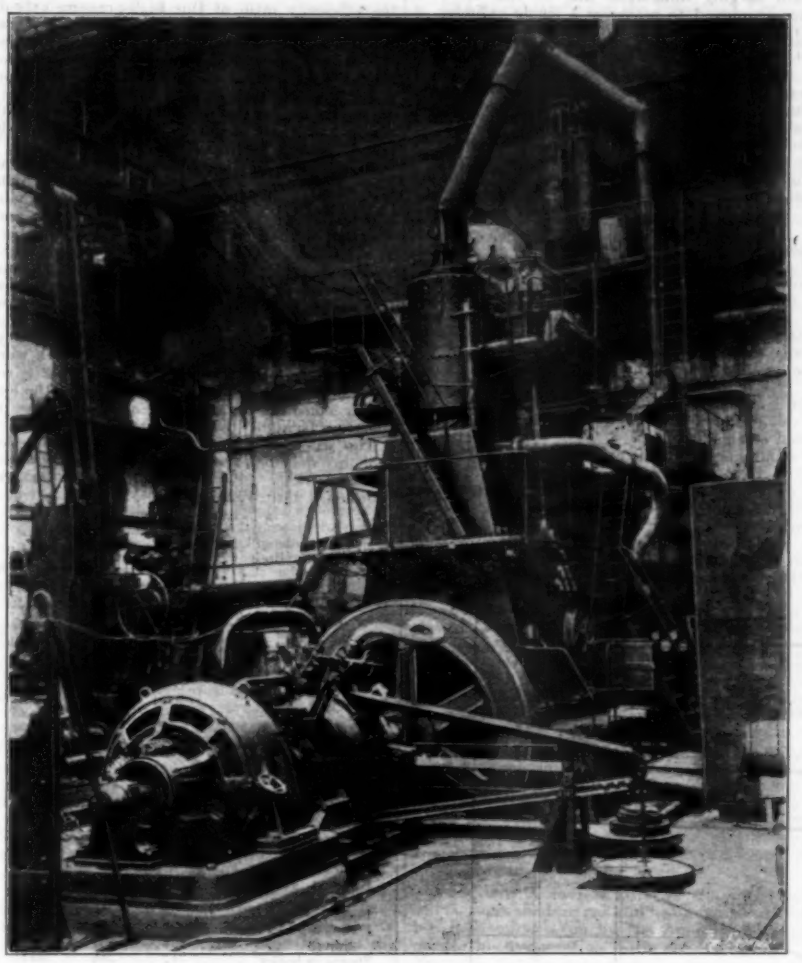


FIG. 8—EXPERIMENTAL UNIT ON TEST-BED

The piston-rod crosshead is of special design. It is well known that the crosshead bearings of most types of Diesel engines are very heavily loaded and frequently give trouble from that cause. In the Still engine, although the load is naturally reduced because of the cycle, the crosshead has been designed to still further reduce the load, and to ensure cool and easy working under all conditions. The design adopted admits of the length and diameter of the pin on its underside being available for the downward combustion load. On its upper side the pin is secured to a saddle, which takes the half bearings for the upward steam load. This saddle is bossed, and provides for the attachment of the complete crosshead to the piston-rod by cottar. In this construction the top and bottom bushes work on different bearing diameters, but these being concentric, no real objection can be taken to the design on this account, and in practice the whole bearing works satisfactorily.

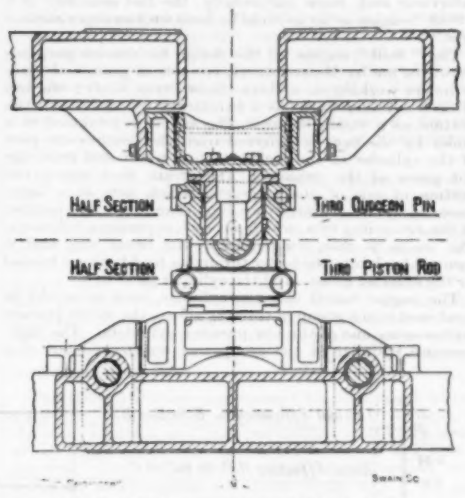


FIG. 10—CROSS SECTION THROUGH COLUMN

The materials of construction call for little remark. The mantle and scavenging belt are made of steel castings, and all other parts of usual materials suitable to their position and function on the engine. Special care and attention was given to the composition and casting of the combustion-cylinder liner and piston head. Such care, however, is not essential to the Still engine—several units already built and working satisfactorily have liners cast of ordinary grey iron—but in the Scott unit it was decided to follow general oil-engine practice in this matter, and use a composition which experience showed to be suitable for internal combustion-cylinder liners. The material chosen has a tensile strength of about 16 tons per square inch, and retains this strength until a temperature of 750 deg. Fah. is exceeded. The amount of growth at the working

REFERENCES.

1. Combustion Cylinder.
2. Reinforcing Steel Hoop.
3. Scavenge Blower.
4. Combustion Exhaust Pipe jacketed by boiler water.
5. Combustion Exhaust Pipe to Feed Heater.
6. Feed-water Heater.
7. Final Combustion Exhaust to Atmosphere.
8. Boiler.
9. Main Steam Pipe.
10. Steam Inlet and Exhaust Valves.
11. Steam Cylinder.
12. Steam Exhaust to Condenser.
13. Condenser.
14. Suction to Air Pump.
15. Air Pump.
16. Feed Pump.
17. Delivery Pipe to Feed Heater.
18. Hot Feed to Boiler.
19. Circulating Water, Boiler to Cylinder Jacket.
20. Circulating Water and Steam, Jacket to Boiler.
21. Auxiliary Oil Burner.
22. Condenser Circulating Pump.
23. Oil Fuel Injection Pump.
24. Oil Fuel Delivery to Injection Valve.
25. Injection Valve.
26. By-pass for Burner Gases.

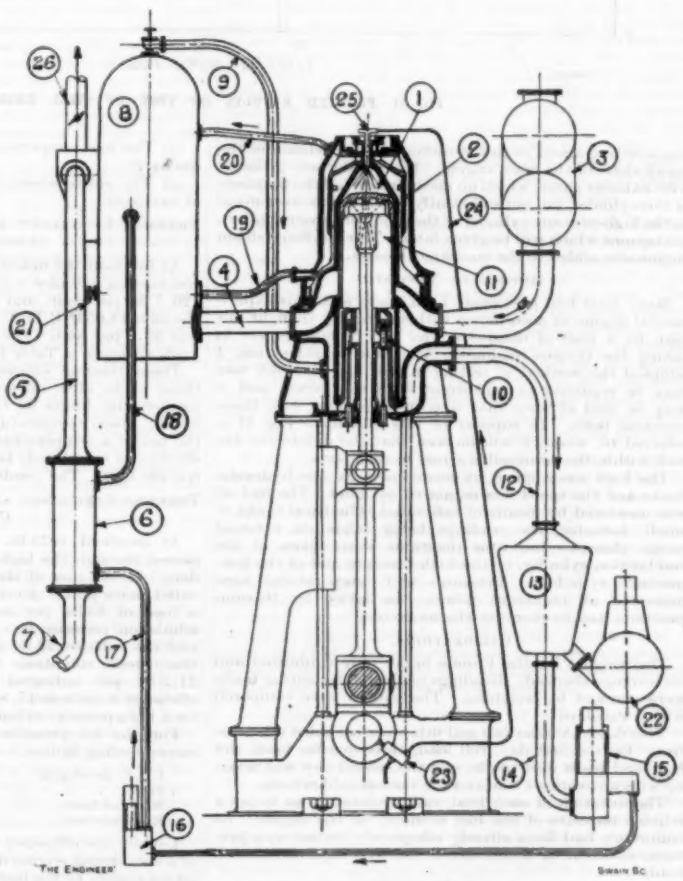


FIG. 9—DIAGRAM SHOWING THE PRINCIPLE OF THE STILL ENGINE

temperatures of the engine is negligible. The Brinell hardness number of this material is 230. Owing to the close ribbing on the cylinder liner and piston head it was thought that some difficulty might be experienced in getting good castings, but such was not the case, satisfactory castings being produced at the first attempt. Prior to dealing with the details of the engine we append Captain Sankey's report.

REPORT ON THE TEST OF A "STILL" ENGINE, CARRIED OUT ON THE 5TH AND 6TH OCTOBER, 1921.

By Captain H. RIALL SANKEY, C.B., C.B.E., R.E. (ret.).

THE object of this test was to observe the general behaviour and, more particularly, the fuel economy of a "Still" engine as far as could be done with an experimental unit.

The "Still" engine, in the design for marine purposes shown to me by Messrs. Scott, consists of groups of three cylinders working on a three-throw crank shaft; the top of each cylinder works as a two-stroke oil engine and the bottom as a steam engine. The steam is produced in a boiler by the heat transferred from the combustion part of the cylinder to the jacket cooling water and from the hot gases of the exhaust. The steam first enters the bottom of one of the cylinders, which acts as a high-pressure cylinder and, after expansion, into the bottom of the remaining two, which act as low-pressure cylinders. The steam is then condensed in the usual way and is pumped back into the boiler through a feed heater—heated by the exhaust gases—and the cylinder jackets.

The engine tested was one cylinder, such as would be combined into a group of three as above, the steam portion representing one of the low-pressure cylinders. The high-pressure cylinder of the group was improvised out of a single-acting steam engine working on an extension of the crank shaft of the main engine. Its cylinder was jacketed with exhaust gases, which no doubt improved the economy of this cylinder, but not sufficiently to make it as economical as the high-pressure cylinder of the group of three cylinders, for reasons which will be given later. This auxiliary steam engine also added to the mechanical losses.

METHOD OF TESTING.

Many tests had previously been made with this experimental engine in accordance with a carefully thought out plan by a staff of observers who had become expert in taking the various readings. After due consideration, I adopted the method of testing in use, and thus my test may be regarded as concurrent with this series, and it may be said at once that it is in agreement with these previous tests. In support of this statement Fig. 11 is referred to, where it will be seen that the differences are well within the permissible errors in such tests.

The load was applied by means of a Froude hydraulic brake and the speed was regulated by hand. The fuel oil was measured by means of calibrated cylindrical tanks of small diameter, the readings being taken on external gauge glasses. Indicator diagrams were taken of the combustion cylinder, of the high-pressure and of the low-pressure cylinders. Pressures and temperatures were measured at numerous points, the latter by thermo-junctions and by mercury thermometers.

CALIBRATIONS.

The weights for the Froude brake were calibrated and its leverage checked. Readings of the oil measuring tanks were checked by weighing. The gauges were compared with a standard.

Two days, October 5th and 6th, were occupied with this test. On the first day, full load, three-quarter load, and half-load trials were made, and the second day was taken up with an overload trial and the various calibrations.

The duration of each trial was regulated so as to get a reliable measure of the fuel economy of the engine; its endurance had been already adequately tested on a previous occasion by a continuous fourteen days' run at full load.

A peculiarity in testing this machine is, that after a substantial change of load—say, from full to three-quarter—some little time must elapse before the temperature distribution throughout the engine and the weight of steam settle down to the *régime* of the new load, and during this time no useful readings to obtain fuel economy can be taken.

The scavenge air was obtained by means of a blower, and after correcting for air blown away to waste to overcome certain surging difficulties due to this form of blower when employed to scavenge a single cylinder, it was found that the horse-power required was as follows:—

Overload.	Full.	Three-quarter.	Half.
20.7	17.7	13.5	6.5

This horse-power has been deducted from the horse-power absorbed by the brake to obtain the effective horse-power given in Table I.

Throughout the test the engine ran perfectly and with very little noise; there was a marked absence of the jar usual in internal combustion engines—in fact, it ran like a steam engine.

RESULTS OF THE TEST.

The essential results of the test are given in Table I. In Fig. 11 are plotted on an effective horse-power basis the total oil consumption, the oil per effective horse-power per hour, the thermal efficiency, the B.Th.U. per horse-power per minute, and the ratio of the effective horse-power to the indicated horse-power at the various loads. Also, by way of comparison, some of the results of the trials made on May 10th, 1921, by a deputation of French engineers.

Attention is called to the following facts:—

(*a*) The remarkable fuel economy and the corresponding high thermal efficiency.

(*b*) The small change in this economy from half to full load.

(*c*) The capability of considerable overload at a comparatively small increase in fuel consumption per effective horse-power.

(*d*) The high brake efficiency for a high compression oil engine.

(*e*) The low consumption of lubricating oil.

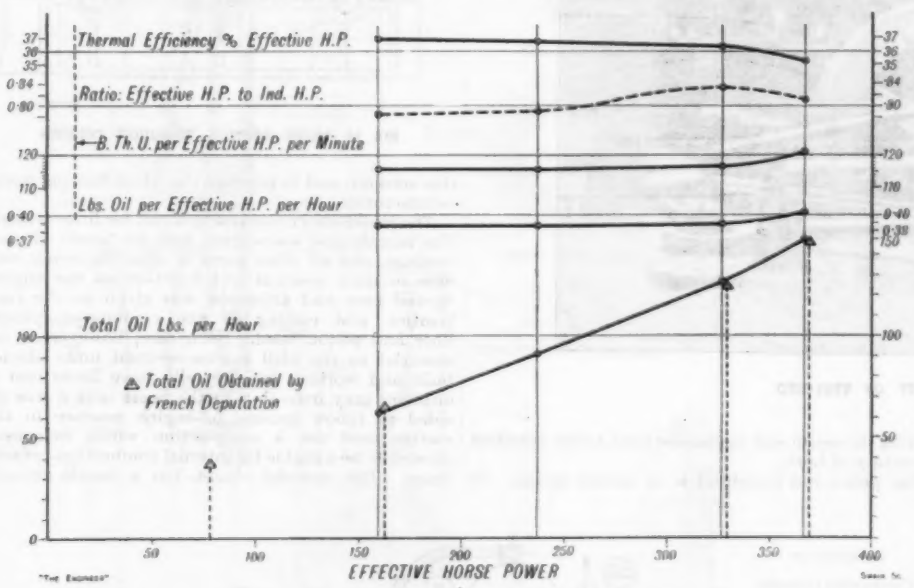

Thermal Efficiency % Effective H.P.
Ratio: Effective H.P. to Ind. H.P.
B.Th.U. per Effective H.P. per Minute
Lbs. Oil per Effective H.P. per Hour
Total Oil Lbs. per Hour
Total Oil Obtained by French Deputation
EFFECTIVE HORSE POWER

FIG. 11—PLOTTED RESULTS OF TEST OF STILL ENGINE

(*f*) The low temperature of the exhaust gases on final discharge.

(*g*) The entire absence of smoke, except a slight haze at overload.

THERMAL EFFICIENCY AND EFFICIENCY RATIO OF COMBUSTION CYLINDER.

At full load the indicated horse-power developed in the combustion cylinder was 351.5, the oil consumption was 126.7 lb. per hour, and since the lower calorific value of the oil is 18,053* B.Th.U. per pound, the thermal efficiency was 39.2 per cent. The thermal efficiencies for the other loads are given in Table II.

These thermal efficiencies have been compared with those of an ideal oil engine working between the same temperature limits as the actual engine at the various loads; these temperature limits have been obtained by the use of a temperature-entropy chart, and the thermal efficiencies calculated, taking account of the variation of specific heat. The results obtained are given in Table II.

THERMAL EFFICIENCY AND EFFICIENCY RATIO OF STEAM CYLINDERS.

At overload 1025 lb. per hour of steam (saturated) passed through the high-pressure and low-pressure cylinders. In the case of the high-pressure cylinder the indicated horse-power developed was 22.8, corresponding to a feed of 45 lb. per indicated horse-power hour. The admission pressure was 111 lb. absolute per square inch and the exhaust 22 lb. absolute per square inch, and for these steam conditions the feed of the Rankine engine is 21.5 lb. per indicated horse-power hour. Hence the efficiency ratio was 47.8 per cent., which is distinctly low for a high-pressure cylinder.

For the low-pressure cylinder the following are the corresponding figures:—

I.H.P. developed	28.9
Feed	35.5 lb. per I.H.P.-hour
Rankine feed	17.1 lb. per I.H.P.-hour
Efficiency ratio	48 per cent.

Usually the efficiency ratio of the low-pressure cylinder of a condensing engine does not exceed 40 to 45 per cent., owing mainly to the loss caused by "cutting off the toe of the diagram." The higher value of 48 per cent. in this case is due to the heat transmitted from the combustion cylinder.

It cannot be doubted that in the actual marine engine of the type previously described, where the high-pressure cylinder is at the bottom of a combustion cylinder, so that the steam receives heat during admission and expansion, the efficiency ratio of this high-pressure cylinder would be at least 90 per cent. As regards the low-pressure cylinder, an efficiency ratio of 90 per cent. can be expected if the back pressure be increased to the release pressure by passing its exhaust into the low-pressure portion of a mixed-pressure turbine provided for driving the scavenge air blower. This turbine should be supplied with a small amount of steam direct from the boiler to make up the power required by the blower and for regulating purposes.

In the experimental engine tested a certain amount of the exhaust gases was used for jacketing the high-pressure cylinder (auxiliary engine); in the three-cylinder unit this waste of exhaust gases would not occur and a corresponding additional weight of steam would be produced in the boiler.

The mechanical losses of the auxiliary steam engine were included when determining the horse-power absorbed by the brake, but in a three-cylinder unit they would not occur. The auxiliary engine is single acting, and, judging from general experience, its mechanical efficiency at 40 lb. M.E.P. would be about 90 per cent., which works out to a loss of horse-power equivalent to $0.0342 \times$ revolutions per minute. Being a single-acting engine the loss is practically constant at all loads, and this horse-power can therefore be added to the effective horse-power.

The calculations to ascertain what improvement in economy may be expected, based on the above, are given in Table III. (Signed) H. RIALL SANKEY.

January 25th, 1922.

* As reported by Mr. Harry Stanger, Broadway House, Westminster.

TABLE I.

Dimensions of engine—
Main cylinder:
Stroke .. .. 36in.
Bore .. .. 22in. diam.
Piston-rod .. .. 6½in. diam.
Auxiliary high-pressure cylinder:
Stroke .. .. 22in.
Bore .. .. 14in. diam.

	Overload.	Full load.	Three-quarter load.	Half load.
Pressures (gauge pounds per square inch)—				
Maximum in combustion cylinder	615	595	600	585
In boiler	114	112	111	111
Admission to engine	96	78	60	29
Exhaust of engine (inches mercury)	26.5	26.9	26.8	25.9
Temperatures (deg. Fah.)				
Exhaust gases, boiler inlet	756	678	579	494
Feed water	78	76	79	78
Exhaust gases to atmosphere	156	164	181	181
Steam in boiler	347	346	345	345
Weight of steam—				
Passing through engine (pounds per hour)	1025	892	583	355
M.E.P. referred to combustion cylinder—				
Combustion	89.53	81.37	71.27	56.63
Steam, high-pressure	5.10	3.86	2.07	1.12
Steam, low-pressure	6.46	6.14	4.75	2.72
Total	101.1	91.4	78.1	60.5
Revolutions per minute	129.3	125.0	111.3	97.4
I.H.P. combustion cylinder	400.5	351.5	274.1	190.6
I.H.P., total	451.7	394.7	300.3	203.5
Brake load (pounds)	1500	1380	1125	850
H.P. absorbed by brake	387.9	345.0	250.4	165.6
Brake efficiency, per cent.	85.9	87.4	83.4	81.4
H.P. used in scavenging	20.7	17.7	13.5	6.5
Effective H.P.	367.2	327.3	236.9	159.1
Ratio, effective H.P. to total I.H.P., per cent.	81.3	82.9	78.9	78.2
Total oil consumption per hour (pounds)	147.2	126.7	90.9	61.0
Oil consumption per combustion I.H.P. per hour (pounds)	0.367	0.360	0.332	0.320
Oil consumption per effective H.P. per hour (pounds)	0.401	0.387	0.384	0.383
Thermal efficiency I.H.P., per cent.	38.4	39.2	42.5	44.1
Thermal efficiency effective H.P., per cent.	35.2	36.4	36.7	36.8
B.Th.U. per minute per C.I.H.P.	110.4	108.2	99.8	96.2
Ditto per effective H.P.	120.6	116.4	115.5	115.2
Lubricating oil per hour (pounds)	0.6	0.6	0.6	0.6
Smoke	Slight haze	None	None	None

TABLE II.

	Overload.	Full load.	Three-quarter load.	Half load.
Thermal efficiency of ideal engine	50.0	50.8	55.0	51.6
Thermal efficiency of actual engine	38.4	39.2	42.5	44.1
Efficiency ratio	76.8	77.2	83.3	85.4

TABLE III.—*Economical Results that may be Expected in a Three-cylinder Unit when the Steam is Exhausted into a Low-pressure Turbine Driving the Air Scavenge Blower.*

	Overload.	Full load.	Three-quarter load.	Half load.
Total I.H.P.	463	404	302	206
Effective H.P.	404	359	256	172
Brake efficiency, per cent.	87.2	88.8	84.6	83.2
Oil per effective H.P. (pounds per hour)	0.364	0.353	0.355	0.355
Thermal efficiency per effective H.P., per cent.	38.7	39.9	39.7	39.7
B.Th.U. per minute per effective H.P.	109.6	106.3	106.8	106.8

Railway Matters.

THE electrification of the Pietermaritzburg-Glencoe section of the South African railways, which will probably be carried out by an English firm, will involve the construction of seventy locomotives.

WE hear with regret of the death on the 12th inst. of Mr. Samuel Richardson Blundstone, Wh. Sc., M.I. Mech.E., who for over thirty years was the editor of our monthly contemporary, the *Railway Engineer*.

THE meeting between the representatives of the English and Welsh railway companies and the National Union and the Associated Society of Locomotive Engineers and Firemen on the 8th inst. made, we understand, good progress before it was adjourned until the following day. The meetings were resumed on Tuesday last.

IN a statement issued last week the German Transport Ministry announced that in consequence of the state of disrepair of numbers of locomotives, it would not be possible to resume full services for some time. The statement added that many locomotives were severely damaged by frost through being suddenly left and neglected by the strikers, and that the amount of the damage thereby caused ran into many hundreds of millions of marks.

THE Council of the Labour Co-Partnership Association, of which Lord Robert Cecil and Mr. W. A. Appleton are joint presidents, has passed a resolution congratulating the railway companies and their men on the establishment of local councils. The resolution adds that, in the opinion of the council, both parties and the general public would gain if the workers were encouraged to share in the ownership of the railways by means of profit-sharing leading to capital holding.

THE annual report of the South-Eastern and Chatham Joint Managing Committee states that it is the opinion of the Committee that before the larger question of forming the Southern Group is considered it is essential in the interests of the South-Eastern and London, Chatham and Dover companies that a complete amalgamation of the two companies should be accomplished. The Committee is glad to report that there is every prospect of an agreement between the two boards. When any agreement is concluded it will be submitted to the proprietors for their approval.

IN addition to the collision on Monday morning in the Summit Tunnel, Walsden, mentioned in this column a week ago, there were three other minor mishaps last week. On Tuesday some wagons on a down train were derailed in Grantham Station, Great Northern Railway, and, fouling the up line, were run into by an up express. Later the same morning the Bradford portion of the 7.15 from King's Cross did not pull up in time when entering Bradford Station and came into collision with some empty coaches. The following afternoon the water scoop of the engine of an up North-Eastern express was wrenched off when near Danby Wiske water troughs, and did some damage to the brake gear and electric light dynamos of the train. It was suggested that the damage was caused by ice on the troughs, but as a train had just previously taken water from the troughs it seems improbable.

THERE was a time when the directors and chief officers of railway companies strongly set their faces against their servants taking any part in public affairs. Now the presence of the latter on such public bodies as chambers of commerce is welcomed, and it is a sign of the times that the *Great Western Railway Magazine* in its current issue says that a considerable number of Great Western men have been elected on public bodies, and in these capacities often find themselves required to deal with questions of transportation, rating, and other matters, in which railway interests are involved. At times they are at a loss for accurate information, as is shown by the fact that inquiries are frequently received from them. The general manager would like it to be understood by all Great Western members of local authorities that if they need enlightenment on any railway subject with which they have to deal, and will make their wants known to the editor of the magazine, every effort will be made to furnish the information required.

ACCORDING to the Board of Trade returns the value of the railway material exported during the past year was as follows, the corresponding figures for 1920 and 1919 being shown in brackets:—Locomotives, £7,936,903 (£5,987,394, £1,781,234); rails, £3,101,280 (£2,698,190, £2,009,184); carriages, £1,567,978 (£1,695,007, £594,352); wagons, £6,023,516 (£5,709,711, £2,374,142); wheels and axles, £1,727,033 (£1,925,007, £821,575); tires and axles, £1,297,700 (£1,417,203, £900,955); chairs and metal sleepers, £1,523,580 (£1,315,802, £317,704); miscellaneous permanent way, £2,657,860 (£2,368,785, £778,905); total permanent way, £10,571,882 (£9,847,168, £3,143,142). The weight of the rails exported was 176,381 tons (131,079 tons, 125,216 tons). During December locomotives to the value of £255,410 were shipped to India and of £36,440 to the Argentine. During the year the value of the locomotives exported to the Argentine, South Africa, India and the Straits Settlements was £247,114, £1,381,587, £3,948,838 and £231,349 respectively.

THE annual report of the London, Brighton and South Coast Company states that although the outbreak of war made it necessary to cancel the main contracts for the completion of the electrification of the suburban railways, it was found possible to continue some of the work. This course was followed because the board was, and still is, convinced from its experience of electrical working, so far as it has been brought into operation, that no better policy can be pursued at the proper time than to extend that mode of working. The work now in progress, viz., the equipment of the railway between Balham and West Croydon, is approaching completion, and the board proposes to complete the suburban scheme as soon as financial and other conditions permit. It was intended to apply to Parliament for additional capital powers, but for reasons that were explained at the annual meeting on Wednesday last, the 15th, this idea has been abandoned. According to Account No. 5 in the annual report, the sum of £44,652 was spent last year on the equipment of suburban lines or felectrical working.

Notes and Memoranda.

AT a recent meeting of the Edinburgh Electrical Society, a paper on "Country House Plant" was read by Mr. T. S. Munnoch. The conditions which govern the class of wiring, size and voltage of plant, were considered. The prime movers—water, steam and internal combustion engines—were compared. The lay-outs of various engine-rooms were described, and the author gave examples from his experience of difficulties which had arisen in the course of erection or running of such plant.

THE Canadian Bureau of Statistics reports that the production of pig iron in the Dominion during December declined to the lowest level for the year, the total amounting to only 39,917 long tons, all of which was made in blast-furnaces. Only two furnaces were active on December 31st, while throughout the greater part of the year at least five furnaces were in operation. The average monthly output of pig iron in Canada during the twelve months ending December was 50,000 tons, or less than the average monthly record for any year since 1908.

THE value of imports into Holland during 1921 amounted to 2,240,219,103 gulden, as against 3,332,427,090 gulden in 1920. Exports totalled 1,369,598,600 gulden compared with 1,701,491,711 gulden for the previous year. Imports from Great Britain were valued at 310,998,317 gulden, the two largest items being textiles (nearly 96 million gulden) and minerals and metals (nearly 73½ million gulden). Holland's exports to Great Britain during the year were valued at 350,236,554 gulden, out of which 166,691,357 gulden was for animals and animal products and over 47½ millions for vegetable products. The gulden is nominally worth 1s. 8d.

THERE is at the present time in course of construction on the river Sila, in the Province of Catanzaro, a hydro-electric plant which possesses several features of interest. The enterprise is that of the Società per le Forze Idrauliche della Sila. Besides being situated at an altitude of some 1235 m. above the level of the sea, the district is furnished with several basins believed to have once been natural, but now dried-up, lakes, exhausted of their contents as the result of some movement of the earth's crust. These natural basins, after the works now in progress have been completed, will form reservoirs from which, by means of two falls of 597 m. and 405 m. head will be made available. As a commencement work has been started on the larger of the reservoirs. It is anticipated that a total of 168,267 horse-power will eventually be obtained. The volume of water to be impounded by the various reservoirs is estimated at 250 million cubic metres, and the total electric energy which will be generated is estimated at 800 million kilowatt-hours per annum.

AN extensive investigation of the corrosive action of soil on pipes used for gas and water mains and service pipes has been undertaken by the American Bureau of Standards, in co-operation with the Bureau of Soils, the Research Sub-committee of the American Committee on Electrolysis, and the pipe manufacturers. Forty localities have been selected as representative of the principal families of soils to be found throughout the United States, and at each will be buried a number of samples of every kind of iron and steel pipe in commercial use, pipes covered with representative pipe coatings, and pieces of lead sheath cable, both plain and armoured. Some of the samples will be uncovered and examined from time to time in order to determine the rate of corrosion. These tests will be supplemented by laboratory tests which will give complete data on the physical and chemical properties of the soil. Other laboratory tests will give the microstructure, complete metallurgical history, and chemical analysis of the pipe specimens. Extensive laboratory experiments will also be conducted to determine the effects of variations in individual characteristics of both soils and pipe materials.

IN the early days of hydro-electric development the buckets used in impulse water wheels were usually made of bronze. Now, according to the *Engineering News-Record*, the majority of impulse wheels are being equipped with steel buckets. Reasons cited by Western engineers in explanation of this apparent change in standard practice are as follows:—The average size of impulse units built ten or twelve years ago was comparatively small; the usual requirements for buckets being such as would best suit jets 2in. or 3in. in diameter. Because of rapid cooling of metal in moulds, it was hard to get first-class steel castings in such small sizes, and the high percentage of rejections on account of poor castings made bronze buckets considerably cheaper than steel. The trend toward larger sizes in recent years is shown by the fact that impulse wheels recently built are driven by jets 10in. or 11in. in diameter and have buckets 28in. to 30in. wide that weigh up to 2200 lb. apiece. In these large sizes the average of steel castings is greatly improved, and because the present steel bucket will outwear the bronze bucket, steel has become the more satisfactory material and is also considered cheaper in the long run.

ACCORDING to the *Pharmaceutical Journal*, many anti-freezing solutions contain glycerine, which is slightly injurious to rubber connections. Glycerine is not, however, used alone, but generally with an alcohol. The following glycerine anti-freezing mixture is for a temperature down to 5 deg. Fah. below zero:—Wood alcohol (by volume), 15; glycerine, 15; water, 70. For a temperature down to 15 deg. Fah. below zero:—Wood alcohol (by volume), 17; glycerine, 17; water, 66. Mixtures of de-natured alcohol or wood alcohol and water lower the freezing point, and are probably the least injurious, though on warm days the alcohol will tend to boil and evaporate. A mixture of 1 part (by volume) of de-natured alcohol and 3 parts of water is said to withstand a temperature of 0 deg. Fah. A mixture of 3½ parts of de-natured alcohol and 6½ parts of water freezes at about 15 deg. Fah. below zero, and a mixture of 4 parts of de-natured alcohol and 6 parts of water freezes at about 25 deg. Fah. below zero. For practical purposes, it is probably better to use only alcohol and water, so that from the specific gravity readings of a motor car radiator solution the amount of alcohol present may be readily determined, and the evaporated alcohol thus may be correctly replaced. This cannot be done when a third substance, such as glycerine, is present.

Miscellanea.

ACCORDING to a law recently promulgated by the "Grand Assembly" of Turkey, motor lorries for public purposes will be admitted into Turkey free of Customs duty. Spares and accessories conforming with the list laid down by the Ministry of National Economy, and oil and petrol will also be admitted duty free.

PRESIDING at the annual dinner of the Carron Company at Falkirk, Mr. George Pate is reported to have said that he could see no grounds for optimism regarding an immediate trade revival. The curtailment of the housing schemes and high railway rates, combined with the aftermath of war, had brought the light castings industry almost to a standstill.

THE chairman of the Soviet Electrification Commission states that the Government proposes to place before the Genoa Conference a scheme for the participation of foreign capital in the future electrification of the whole of Russia, by means of the establishment of a bank in Russia with the assistance of foreign capitalists. A period of twenty years is fixed for the execution of the work, the first instalment representing an expenditure of 2,000,000,000 gold roubles.

AN exhibition of industrial heating apparatus, to be held in April of this year, is being organised by the Office Central de Chauffe Rationnelle, Paris, under the patronage of the Société d'Encouragement à l'Industrie Nationale and the Société des Ingénieurs Civils de France. The Exhibition will comprise apparatus and material connected with "la conservation et la récupération" of heat, and it will be divided into two sections, one including refractory materials, insulators, &c., and the other apparatus and plant, such as economisers, heat-recovery plants, &c. Every facility will be given for experimental demonstrations of exhibits.

THE latest statistics concerning China's mineral output show that, while that country covers about 7 per cent. of the earth's surface, and has a population equal to a quarter of the whole globe, the mineral production is less than 1 per cent. Out of thirty-two substances enumerated, only antimony and tungsten are above 10 per cent.; tin and mercury above 5 per cent.; zinc, arsenic, coal, asbestos, magnesite and talc above 1 per cent. Substances of fundamental importance to national industry, such as iron, copper, petroleum, and sulphur are very insignificant in amount, whilst phosphates, nitrates and potash, so necessary to modern agriculture, have not yet been found in any quantity.

SPEAKING recently at the Manchester Rotary Club, Mr. E. O. Walker said that it was difficult to make electricity remunerative in districts where only a few lights were used for an hour or two a day, and for such consumers a charge of 1s. a unit was not too high. What was wanted was a class of customer which would take a regular supply distributed as evenly as possible over the twenty-four hours. In any case, the plant had to be kept constantly running, and electricity could not be stored so effectively or inexpensively as gas. Mr. Walker mentioned some of the many advantages of electricity, and said that in this country electricity was in its infancy as compared with America and the Continent.

IT is reported by the National Federation of Iron and Steel Manufacturers that the production of pig iron in January amounted to 288,000 tons, a figure higher than in any month since March last, but less by 354,000 tons than the production in January last year. The furnaces in blast at the end of January numbered 90, compared with 77 at the end of December and 242 at the corresponding date last year. Of the production of pig iron in January, 102,900 tons were hematite, 84,700 tons basic, 68,300 tons foundry, and 16,900 tons forge. The production of steel ingots and castings in January showed a further decline to 327,500 tons, compared with 381,000 tons in December and 448,800 tons in November.

THE plan of the ultimate development of the Feather River in California contemplates a series of seven power-houses, all successively utilising the controlled waters of Lake Almanor in addition to the annual run-off of the watershed between the power-houses and the lake. The total head which will be utilised by the seven power-houses is 3547ft., or 85 per cent. of that available in the river. The total possible power development is 486,000 kilowatts. The largest single development will be Caribou, with 120,000 kilowatts; the smallest, 25,000 kilowatts. The highest single head will be 1008ft.; the lowest, 270ft. The total length of tunnels required is approximately 103,000ft., of which Caribou has a considerable portion.

THE industrial situation in Italy is described in Italian official circles as being generally good, especially when the condition of industry throughout the world is taken into consideration. The metallurgical industry is to a great extent at a standstill, but there are signs of a revival. Engineering has also suffered from the abnormal conditions which prevailed after the war; but many works have maintained their full-time activity. The competition from the countries of Central Europe, with the advantage of their excessively depreciated exchanges, constitutes the most serious obstacle which Italian industry has to overcome, but this competition is now less conspicuous, as such countries are likely to be engaged for several months in the execution of orders already received.

IN connection with the air taxi services that are to be run this year to connect with the arrival and departure of liners at Southampton and Liverpool, states the *Manchester Guardian*, arrangements are to be made for the ordering of these taxiplanes by wireless while the liners are still far out at sea. These wireless orders will be picked up direct by the wireless operators at the London air station, and will be in the hands of the air taxi pilots within a minute or two of being despatched from the liner. In this way a passenger arriving in Britain from overseas who wishes to be at his destination at the earliest possible moment can be sure that there is an air taxi waiting for him when his liner berths. New air taxis, to cope with the greatly increased demand expected this year, are now being built. They include two, three and four seaters, and fares will be as low as 10d. per mile per passenger.

HYDRO-ELECTRIC PLANT AT WALKERBURN, PEEBLESSHIRE

(For description see page 173)

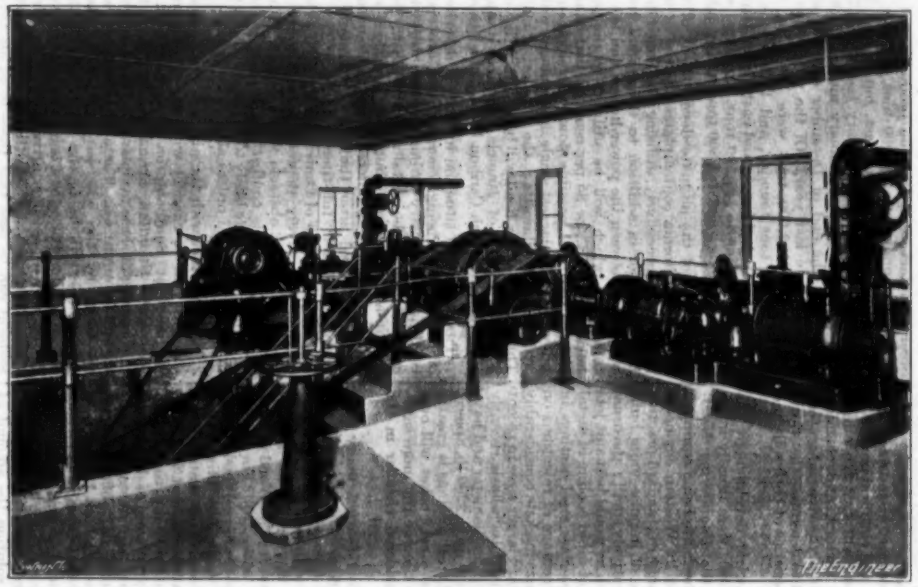


FIG. 8—INTERIOR OF POWER HOUSE

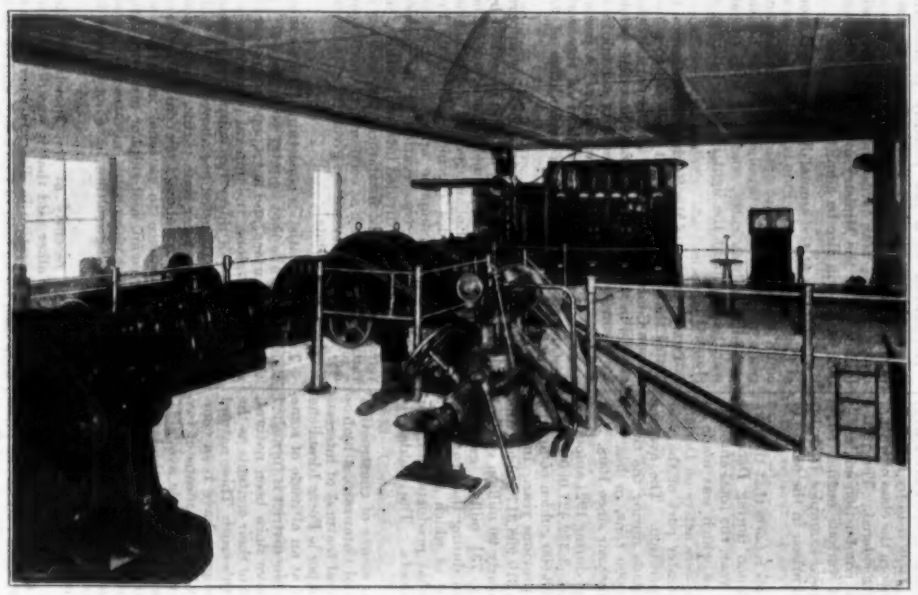


FIG. 9—INTERIOR OF POWER HOUSE

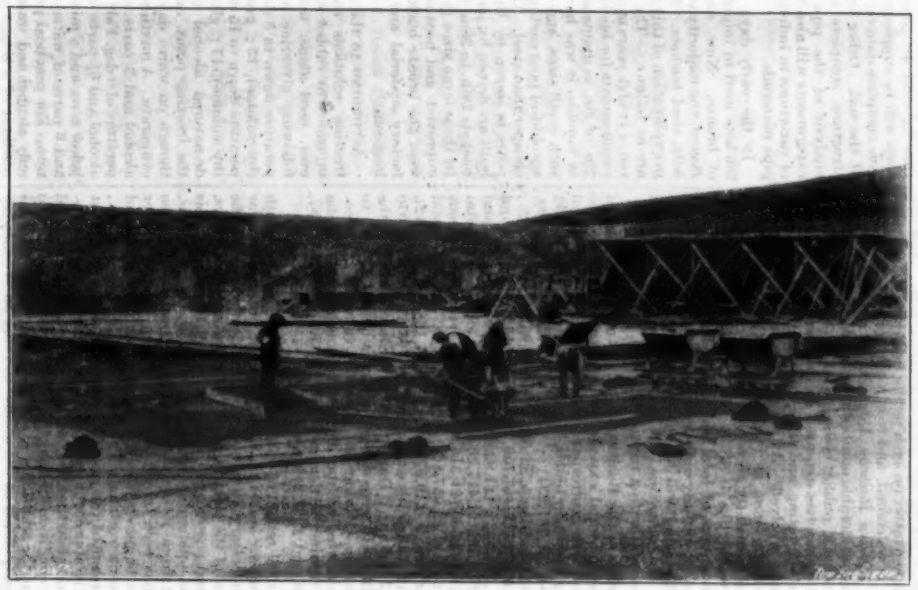


FIG. 10—THE RESERVOIR DURING CONSTRUCTION

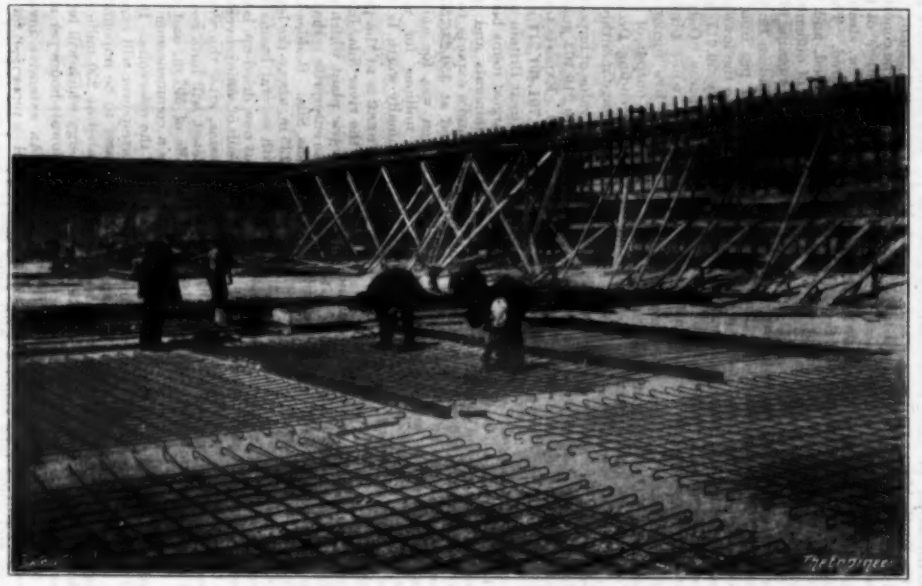


FIG. 11—PLACING REINFORCEMENT FOR FLOOR OF RESERVOIR

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Letters relating to Advertisements and the Publishing Department of the Paper are to be addressed to the Manager, all other letters to be addressed to the Editor of THE ENGINEER.

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PUBLISHER'S NOTICES.

*** *With this week's number is issued a Two-page Supplement illustrating an Ice Factory at Grimsby. Every number as issued by the Publisher contains a copy of this Supplement, and Subscribers are requested to notify the fact should they not receive it.*

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*** *We cannot undertake to return drawings or manuscripts; we must therefore request correspondents to keep copies.*

By arrangement with Reuter's Engineering Service, **The Engineer** *contains the latest news from all parts of the world which is likely to be of interest to engineers.*

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TWO-PAGE SUPPLEMENT—ICE FACTORY AT GRIMSBY.

THE ENGINEER.

FEBRUARY 17, 1922.

The Buxton Explosion.

IT is many years since a boiler explosion has caused such widespread interest in engineering circles as that which occurred in the marshalling yard at Buxton on November 11th last, and it is many years since an accident of the kind presented so much difficulty in the search of the cause. The report by Major Hall, of the Ministry of Transport, and Mr. Cranwell, of the Board of Trade, is an exceptionally long document, resulting from an exceptionally searching inquiry, but we doubt if the conclusions arrived at can be accepted with complete confidence. These reporters condemn the safety valve, but only on indirect or circumstantial evidence, for the valve of the ill-fated engine was so damaged and jarred by the explosion that any positive evidence it might have afforded could not be, in the circumstances, expected. Indeed, the one small piece of positive information it gave does not support the verdict. Both valves are assumed to have stuck fast against a pressure which we may presume to have been in the neighbourhood, let us say, of 500 lb. per square inch, yet when the valve column was examined after the accident the one valve which remained in position was free on its seat. But if we do not accept the conclusions of the reporters, what explanation is there to offer? It is clear from the nature of the *débris*, the distances to which parts were hurled, the tearing of plates which tests showed to be of first-class material, and the complete displacement and dislocation of the whole engine, that the explosion was of a very violent nature, that it was, in fact, of a kind that we associate with extremely high tensions. It could only be brought about by a gradually accumulated excessive pressure or by a rapidly generated excessive pressure. The second alternative might have been advanced with success some years ago, when the spheroidal condition was believed in, but would not be accepted now, and it is impossible to see how a force sufficient to burst a sound boiler could have been generated except in the usual way. Hence we are practically driven to the conclusion that both the valves stuck fast, and to accept, in the lack of a better, the reporters' verdict.

There are two aspects of this strange accident, the human and the material. The former may be quickly dismissed. On several occasions prior to the explosion, and by several different drivers, the fact that the gauge registered excessive pressures had been noticed; but, as far as we can see, on not one of these occasions did the man satisfy himself by touching the lever that the safety valves were free. There is no evidence that even in the shed were the valves tested. The reason for this fatal neglect of what would appear to be the simple and most obvious precaution is to be found partly in the implicit confidence which drivers put in the safety valve, and partly in the fact that the lever is not readily accessible. Had the tail of it protruded into the cab we cannot doubt that the drivers would have touched it. But it did not do so, and to reach it the man would have to stand upon the running board and probably make a "long arm" with some handy tool. Some locomotive engineers object to the tail of the lever entering the cab, because they fear that in the movements of the engine it may seize against the sides of the slot through which it passes. That contingency can, obviously, be easily avoided, and, even if the tail did catch, it could not prevent valves of the Ramsbottom type from operating freely. It might, indeed, cause one of the pair to open, and that is the worst it could do. We suggest that in view of this accident, in view of the doubt that has been thrown upon the infallibility of the safety valve, all such valves should be so fitted that the driver can at any moment assure himself that they act freely. . . . Let us now turn to the material cause or causes of the disaster. Here we have but two things to consider if we may assume, as presumably we may, that the boiler was strong enough for its working pressure. These two things are the gauge and the safety valve. Four times the gauge was reported as defective, but there is reason to believe that there was nothing the matter with it. The valves were never suspected, yet the reporters are confident that they stuck. If this conclusion is correct—and we admit we can see no other—then the explosion is explained; but the reason for the sticking of the valves remains a mystery, which can only be solved by careful experimental investigation. Calculation is practically defied, because the essential quantities are unknown. The valves were of the wing pattern, with three wings; they were of gun-metal, and fitted into gun-metal seats or bushes, which were pressed into a cast iron body and pinned in position. They were fitted in the usual way by feel, that is to say, the edges of the wings, after turning, were, if necessary, draw-filed until they slid easily and freely in the seats. The actual clearance was not specified. On the Midland, we believe, eight thousandths of an inch on the whole diameter of three inches has been found ample. It is not likely to have been less in this engine, and appears, from Mr. Cranwell's examination, to have been rather more. The valve seats were not perfectly circular, and in some positions of the valve there was less clearance than in others. But the minimum by the ring and plug test was .0095in. in the front seat and .0120in. in the other. But—and here lies the real difficulty of explanation—the valve had blown freely at the set pressure for many weeks, and furthermore, whilst we may imagine one valve sticking owing to excentricity or other cause, it is hard indeed to understand why both should bind simultaneously. Tests made by Captain Beames on a number of other valves are far from conclusive. They showed that in some cases the valves failed to blow at 220 lb., and in one case there was persistent initial sticking of both valves, which was only relieved by hammering the valve body, but the inquiry was apparently not pushed far enough to assign a cause. The excess steam pressure employed was only some 20 lb. or so, and in the ill-fated engine it would seem necessary to assume from the nature of the explosion that a pressure of something nearer 500 lb. was generated. Such a pressure would result in a load on each valve of about one ton and a-half. Two-fifths of that load would be taken by the spring, leaving roughly nearly one ton to overcome the assumed adherence between the valve wings and the seat. It is difficult to understand why one valve which, up to a short time before, had been operating properly, should bind against a load of that order; it is five or six times more difficult to understand why two valves should do so. Indeed, we can only explain such a coincidence on the assumption that there was, in fact, no real coincidence, and that some indefinite time prior to the accident one of the valves had ceased to act, and that a few weeks before November 11th the other had begun to exhibit a similar defect. But even then we are little or no nearer the cause of the sticking. Mr. Cranwell asks us to believe that the climatic conditions had something to do with it, and points to the fact that all through the warm weather the valve worked well, but failed when it turned cold. The argument is quite inconclusive. If the boilers had been re-started in service in November instead of in August it is probable the valves would have stuck in warm weather instead of cold. We dismiss that view altogether, especially as we are aware that experiments have been made by driving cold blasts of air on to the

columns of Ramsbottom valves without the slightest effect. The internal heat is far too much above that of the external air for any atmospheric changes to effect the form of the seats to a measurable degree. A few figures on this point may prove of interest. Taking the wholly unlikely circumstance that the valve bush remained at a temperature of 40 deg. Fah. whilst the valve reached 470 deg. Fah.—the temperature of steam at about 500 lb. abs.—then an original clearance of eight one-thousandths would be reduced to a minus clearance of five one-thousandths. If, however, we assume that the ring was at a temperature of no more than 160 deg. Fah., then a tight sliding fit is restored. Hence we conclude that if the valves did stick it would be better to look for the cause in some changes in the poppets or seats themselves under the influence of heat changes than for distortion of the columns caused by the weather. But against this cause we have to set the fact that the valves were old, that the wings were not touched during repairs, and that the only change was a slight skimming of the seating face, with a reduction of the angle from 45 deg. to 30 deg.

On this question of the angle of the seats a good deal has been said during the past months. In some of the repaired engines the contained angle of seats was 90 deg., in others less. Experiments made by Mr. Cranwell showed that the angle had no influence—that under all conditions 60 deg. acted as well as 90 deg. We are thus forced to look to the wings and to the wings only, and we have to ask ourselves if it is possible that the smallish area of contact—an indefinite amount—between the wing edges and the bush could be sufficient to resist the tearing action set up by a load of about one ton. No amount of calculation can settle that point, but a few simple experiments would readily resolve it. We trust they will be made. We suggest particularly that a test should be made with 30 deg. angle, with the wings not perfectly concentric with the seat. That the wing valve has a tendency to stick and that in certain circumstances it will stick uncommonly tight is well known. For this reason some makers will not use such valves, but prefer either external guides or wingless valves. The Ramsbottom safety valve can be made quite well in the wingless form, and doubtless would always have been so made had trouble ever arisen. But it had not. For many years the wing valve has worked so satisfactorily that no one ever thought of suspecting safety valves. If anything was wrong it was the gauge; never the valves. There is, therefore, no good reason for pressing for a change of design, but we submit, again, that there is every reason for providing always, as some engines are now provided, simple means by which a driver may instantly satisfy himself that the safety valves are free. We cannot imagine a more elementary precaution in a safety device. With the two recommendations made by the reporters, first, that the valve seats should be bored after pressing into their seats and that clearance should be standardised, and, secondly, that whenever a steam gauge is changed it should be tested against the safety valve, there can be no quarrelling.

There is an old saying that every riveted boiler in good condition is its own safety valve. Years ago Webb tried to burst a boiler and failed because the joints opened and relieved the pressure before explosion occurred. Sir John Dewrance tells us that a similar test with similar results has been made on Babcock's steam drums. If the boiler at Buxton failed, as apparently it did fail, from very excessive pressure, why was there no indication of the fact by leaky joints either on the day of the accident or on the few preceding days when the gauge pin went hard against the stops and the valves did not blow? Was the boiler actually in prime condition on November 11th, or had the box already begun to exhibit defects under the stress of excessive pressure? These are points that have to be thought of. We must ask ourselves also if it was a mere coincidence and nothing more that the boiler went up a few seconds after the regulator had been opened? And, finally, we must ask ourselves, remembering that the one valve remaining in position showed no defects, did the valves actually stick, did some other cause operate to prevent their opening, or was the violence of the explosion caused by the sudden generation of steam after—and not before—the primary failure of the fire-box? Could we believe that the boiler was carrying a pressure of not more than 250 lb. to 300 lb. just prior to the explosion we could accept the sticking valve theory—the only one that so far presents itself—far more readily than if we are forced to believe that a pressure twice as great existed in the boiler and failed to force the valves open or to cause visible leaks. Indeed, we may confess that it is to some such explanation that we lean, and we note in this connection that the hydraulic test was taken no further than 205 lb. According to Mr. Tizzard, of Crewe, the London and North-Western practice with an old boiler is "just to give it its working pressure in steam." In his examination he admitted that if 300 lb. were carried there would be danger of the crown coming down. Whilst it is still difficult to explain the sticking of the valves after they had operated correctly for many months, it is a more readily acceptable explanation if we assume that the pressure was no more than 300 lb. than if, following the test made in a similar boiler at Crewe, we are forced to believe that it would not fail even at 600 lb.

Air Conference Reflections.

AT a moment when the cry is for economy in the administration of the departments of the State and proposals have been put forward for drastic cuts in the expenditure on the defence forces of the country, it was appropriate that a Conference should be held at which the position and policy of the Air Ministry was reviewed. It will not be denied by those who were present at last week's gathering, and it should now be clear even to those who have only derived their impressions from the reading of newspaper reports, that those who believe in the future of Service aviation and commercial air transport are only at the beginning of a difficult task. Captain Guest told the Conference that the Ministry has had to fight for its life against the two older services, the members of which have carried on persistent efforts to absorb the Air Ministry into the Admiralty and War Office. These efforts have been defeated, and now the Geddes report has suggested the absorption of the Admiralty, War Office and Air Ministry into a Defence Department, which, it is believed, might succeed in welding the whole of them into an administration which would co-ordinate effort and serve the national needs at far less cost than three separate Ministries, which, owing to inter-departmental jealousy, tend to work in water-tight compartments.

The political and administrative aspects may be left to those whose business it will be to decide the issues which have been raised. There are, however, other points of view which demand attention. It was made quite clear at the Guildhall last week that Service and civil aviation are two branches of the same problem, and are more closely related than the Navy and the mercantile marine. There is no demand at the present time to create more than a nucleus of a war air force; the time is not propitious for any ambitious scheme, even if the technical side of the problem had been solved. It is claimed that at the close of the war period we had attained the first place in aeroplane design and construction, and even to-day, although the technical staffs have been to a great extent disbanded and scattered and the manufacturing industry allowed to wither, it is the British designed and built aeroplane which finds most favour with airmen. The place won by Great Britain for heavier-than-air machines is held by Germany for airships, and whatever may be the future *rôle* of the aeroplane and airship in times of war, it is held that both these organs of transport have their place in commercial aviation. Ironical as it may appear, it is possible indeed that in the opening up of Empire air routes, it is the German-type airship which may play the main and the aeroplane the subsidiary part. Leaving Service aviation to work out its own destiny, it will be of interest to devote consideration to the present position of commercial aviation, which must, it should be clearly understood, form the reserve from which a war force would be expanded to the necessary magnitude. The education and training of designers, the existence of a large-scale manufacturing industry capable of diverting its energies from peace to war work at short notice, the reserve of machines which, although built for civil work, would be capable, in the hands of trained pilots, of carrying on military operations, and the provision of a reserve of skilled pilots can only be achieved if commercial air transport is developed into a great and prosperous industry. The soundness of this argument being acknowledged, it is pertinent to inquire what light was thrown by the Guildhall gathering on the prospects of bringing into existence at an early date a civil aviation industry of any real magnitude. He would be an out-and-out optimist who could pretend that much encouragement can be drawn from the proceedings at the Air Conference. There is no need for undue pessimism, but it is essential, if any real progress is to be made within a reasonable period, that the difficulties should be faced. Lord Weir, who cannot be accused of belonging to a hostile party, regards the results which have been achieved as exceedingly meagre, and as prodigal in life and cost. This brief review of the situation with which the discussion was opened laid down the lines of a debate which served not only to show the defects of the present position, but the kind of remedies which will have to be applied.

In the report of the Conference, which appears in to-day's issue, the reasons for the slow growth of civil air transport are revealed. It is uncommercial, and it is unsafe. The existing services, which can only be regarded as full-scale experiments, are only made possible by means of a subsidy, and the accident ratio is extremely high. The comparison may be an unjust one, but a speaker at the Conference stated that if the accident percentage were as high on the London tube railways as on the existing air services, 300 persons would be killed every day. The truth is, as Lord Weir argued, that the types of aeroplane now in service are not suitable vehicles for commercial transport. They are the heritage of the war, and full of pride in the achievements of our airmen during 1917 and 1918, the vast difference between Service and civil aviation has not been fully realised. To some extent it will be necessary to begin *de novo* and to devote fresh attention to the theoretical side. Both Sir Richard Glazebrook, who made a strong plea for more fundamental research, and Professor Burstall, who discussed engine problems, indicated the limitations in existing circumstances of *ad hoc* investigations. These are necessary, of course, and the mere recital of the work in hand at the National Physical Laboratory, the Royal Aircraft Factory and the Universities would surprise those who have not been in touch with recent developments. The real need is, however, for something more than improvements in detail, and we hope that the demand for funds for unfettered fundamental research will not even to-day be disregarded. It is a national requirement to bring into existence at the earliest possible moment a large and prosperous civil aviation industry. This can only be done by providing machines which are safe and comfortable for passengers, and by quoting fares and rates which will attract traffic. Admitting that the services now in operation are over too short a distance to reveal the advantages of air transport, the results, both on the passenger and goods sides, have been very disappointing. We are now, perhaps, getting near the end of the experimental period, and there were plain indications given at the Conference of an intention to go ahead as fast as possible. There is even a suggestion to commence a service to India; and, heartened by the definite statement of Sir Richard Glazebrook that a commercial airship can be designed and built in Great Britain, the opening up of the Empire route to Australia is to be pressed on the Government.

AN ALTERNATIVE WATERWAY.

WHILE the project to provide a great international channel for ocean-going ships by improving the St. Lawrence River to the Great Lakes is being studied by the Governments of the United States and Canada, supporters of an alternative plan, the proposed Ottawa and Georgian Bay Canal, are endeavouring to enlist support for their "all-Canadian" waterway. The advantages claimed for that route over the St. Lawrence ship channel include its route, which lies entirely within Canadian territory, its immunity from the storm hazards of the Lakes, and the saving it offers in mileage. According to reports of the Canadian Government engineers who have made an exhaustive study of the project, the Ottawa and Georgian Bay Canal scheme is practical for the Government to undertake. As surveyed, the canal would follow the St. Lawrence from Montreal to the junction of the Ottawa and St. Lawrence Rivers; thence the Ottawa would be followed to Mattawa; and Lake Nipissing and the French River would provide an outlet from the Ottawa River to Lake Huron. The total length of the canal would be 440 miles, with a total lockage of 758ft., the number of locks being twenty-seven, with lifts ranging from 5ft. to 50ft. The size of the locks would be uniformly 650ft. in length, 65ft. clear width and 22ft. depth; 22ft. would be the minimum depth on the entire length of the waterway, which would consist of 28 miles of canal proper, 66 miles of improved river navigation, and 346 miles of river and lake, varying in width from 300ft. to half a mile.

IF the general meeting of the International Railway Association agrees at its meeting in Rome in April, the next congress of the Association will be held in Madrid in 1927.

Obituary.

SIR GEORGE JOHN CARTER.

THE shipbuilding industry in general, and the firm of Cammell Laird and Co., Limited, in particular, have suffered a severe loss by the death of Sir George Carter, which took place on Thursday of last week at Brettanby Manor, in Yorkshire, the seat of his brother-in-law, Lieut-Colonel E. Vaux. For some considerable time Sir George's health had been indifferent, but it was only during the last week or two that his condition was regarded as being serious.

George John Carter, who was the son of the late Mr. George Dean Carter, was born in 1860, and at the very early age of fourteen years he was entered at Portsmouth Dockyard as a shipwright apprentice. During the seven years of his apprenticeship he passed through all the departments and gained a thorough insight into the methods of shipbuilding employed at that Government establishment. He remained at Portsmouth in all eleven years, the four years succeeding the period of apprenticeship service being spent in the drawing-office. In 1886, when twenty-six years of age, he was offered and accepted a position in the Elswick Works of what was then Sir W. G. Armstrong, Mitchell and Co., but which, of course, afterwards became Sir W. G. Armstrong, Whitworth and Co., Limited. There, his abilities soon made themselves felt, and eight years later, when he was but thirty-four years of age, he was given the important post of shipyard manager. Later still he was made a director of the company. In all, Mr. Carter, as he then was, remained with the Armstrong firm for twenty-five years. During that quarter of a century he was concerned in the construction of very many warships for the home, Argentine, Brazilian, Chilian, and Japanese Governments, including battleships—the most noteworthy of which was perhaps the Minas Geraes—armoured and unarmoured cruisers, destroyers, torpedo boats, training ships, and Royal yachts, while numerous merchant vessels were built under his supervision. The decision of the firm to found a new shipbuilding yard at Walker-on-Tyne is said to have been arrived at largely as the result of his representations, and in the planning of that establishment he played a leading part.

Towards the end of 1912, Mr. Carter resigned his position at Elswick in order to take up the appointment, in succession to Mr. Ratsey Bevis, of managing director of the Birkenhead yard of Cammell Laird and Co., Limited—a post which he filled with the utmost distinction. Just previously he had been appointed a director of the company. As a result of his control, the output of the yard immediately increased, and by reason of the augmentation of equipment and the reorganisation which were effected under his *régime*, the works were enabled to play a most important part in the war. During the period of hostilities a vast amount of work was got through, and owing largely to the able management of Sir George, the building period of all types of vessels was very considerably expedited. In some cases the completion of ships was effected more quickly by as many as from seven to eight months than under ordinary peace conditions. The yard is unusually well supplied with graving docks, and its new managing director had seen to it that the machinery specially adapted for ship repairs had been brought well up to date—for in pre-war times it did a large business in that direction—so that when the war came it was eminently suited for the carrying out of the vast amount of reconditioning which had to be done, not only to vessels of the British Navy, but to those of the American Navy as well. The United States destroyer fleet, in fact, made it its chief refitting centre. It was for the invaluable services which he rendered during the great struggle that Mr. Carter was created a K.B.E. (Civil) in the year 1917.

Considering the demands made upon his time by his own special business, Sir George managed to give a large amount of attention to other matters. Whilst at Newcastle, besides being a Justice of the Peace for the County of Northumberland, he was a member of the Tyne Improvement Commission, and a Vice-president of the North-East Coast Institution of Engineers and Shipbuilders. He was also an officer in the 1st Northumbrian Royal Field Artillery (T.F.), and commanded the Elswick Battery before it was taken over by the Territorial Force. At Birkenhead he became a member of the Mersey Docks and Harbour Board and a director of the Coventry Ordnance Works, Limited.

During the whole of the war period Sir George was President of the Shipbuilding Employers' Federation. He was also chairman of the Merchant Ship Advisory Committee to the Shipping Controller, and subsequently a member of the Shipbuilding Council. In these capacities he was closely identified with the building of large numbers of standard merchant ships, and rendered invaluable services to his country and to the cause of the Allies generally. Nor did these labours sum up the whole of his activities, for he was also chairman of the Liverpool Munitions Committee. In all that he did he evinced such an astonishing alertness and grasp of detail that his services were continually being sought in every direction. It is only too certain that it was the self-forgetting strenuousness of his work during the whole of the war period which led to his premature and most regrettable death.

Sir George was a member of both the Institutions of Civil and Mechanical Engineers; a member of Council of the Institute of Naval Architects, and of the Federation of British Industries; a member of Committee of Lloyd's Register, and a freeman of the Shipwrights' Company. He was a man who was universally respected and loved; masters, colleagues and men all admired him. He was held in especially high esteem in labour and trade union circles by reason of his fair and honest dealing in all questions affecting the conditions of labour, rates of pay and welfare of those employed in the shipbuilding and engineering industries. In all cases of negotiation with the employees of the firms which he served, he displayed a fairness and undeviating honesty which rendered him extraordinarily popular with all classes. He was a man of a type of which to lose one is in the nature of a national calamity.

SIR GEORGE JOHN CARTER

We cannot, we think, conclude this memoir more fittingly than by printing the following appreciation which is from the pen of one who had known Sir George intimately for many years, and who appreciated his many sterling qualities at a very high value:—

"The impression that one got in meeting Sir George Carter was that of a splendid specimen of virile manhood. Everything about him was on rather more than the mere "full size" scale. He was a big man, well proportioned, a born leader, and his favourite methods can best be described as Napoleonic. Possessing large ideals, immense energy and a wide outlook, he nevertheless found time and opportunity to associate himself with details and activities that many another man in his position would have considered too trivial to waste time over. At the same time, no one could get at the essential points of an apparently hopelessly complicated case more quickly, and having done so, he invariably came to a decision with unerring instinct, and without a moment's delay. It was this rare faculty that made him so valuable in committee, especially when dealing with labour problems. In nine cases out of ten, any questions in dispute were settled out of hand after a frank and free discussion. Always a firm believer in the rights of organised labour, he had the full confidence of the trades union officials, who knew quite well that if they could put up a sound case he would be their most powerful advocate with his own colleagues.

"His attitude towards his own staff and workmen was ever that of a benevolent despot. In the equipment of the works, in the provision of labour-saving apparatus and safety devices, in ambulance and first-aid requirements, in canteen accommodation, no trouble and no expense were spared in looking after the welfare of the thousands of men and boys whom he always considered as being committed to his charge. He was one of the first to inaugurate a system whereby workmen were encouraged to invent improved appliances. On proof of value, suitable awards were made and patents taken out in which the employee participated.

"Even outside the works and outside of working hours, Sir George's interest in his employees permeated. Clubs were established, sports grounds laid out, and a convalescent home acquired. All apprentices and boys were expected to attend the local technical schools, where the fees were paid for them, and their wages were raised by a graduated bonus according to the degree of success attained at school and in the works. The poorer boys of the town belong to a Shaftesbury Club, of which Sir George was President. Busy as he was with his own particular work, and the various councils and committees that claimed his attention, he was always to the fore in social engagements, in which, it is only fair to state, he was ably supported, and often led, by his gifted and devoted wife.

"It is recalled that in 1920, when the Institution of Naval Architects held its Summer Meeting in Liverpool, Sir George was chairman of the local Reception Committee, and threw himself heart and soul into the work of arranging meetings and functions, although he was even then suffering from the first attacks of the malady that eventually carried him off.

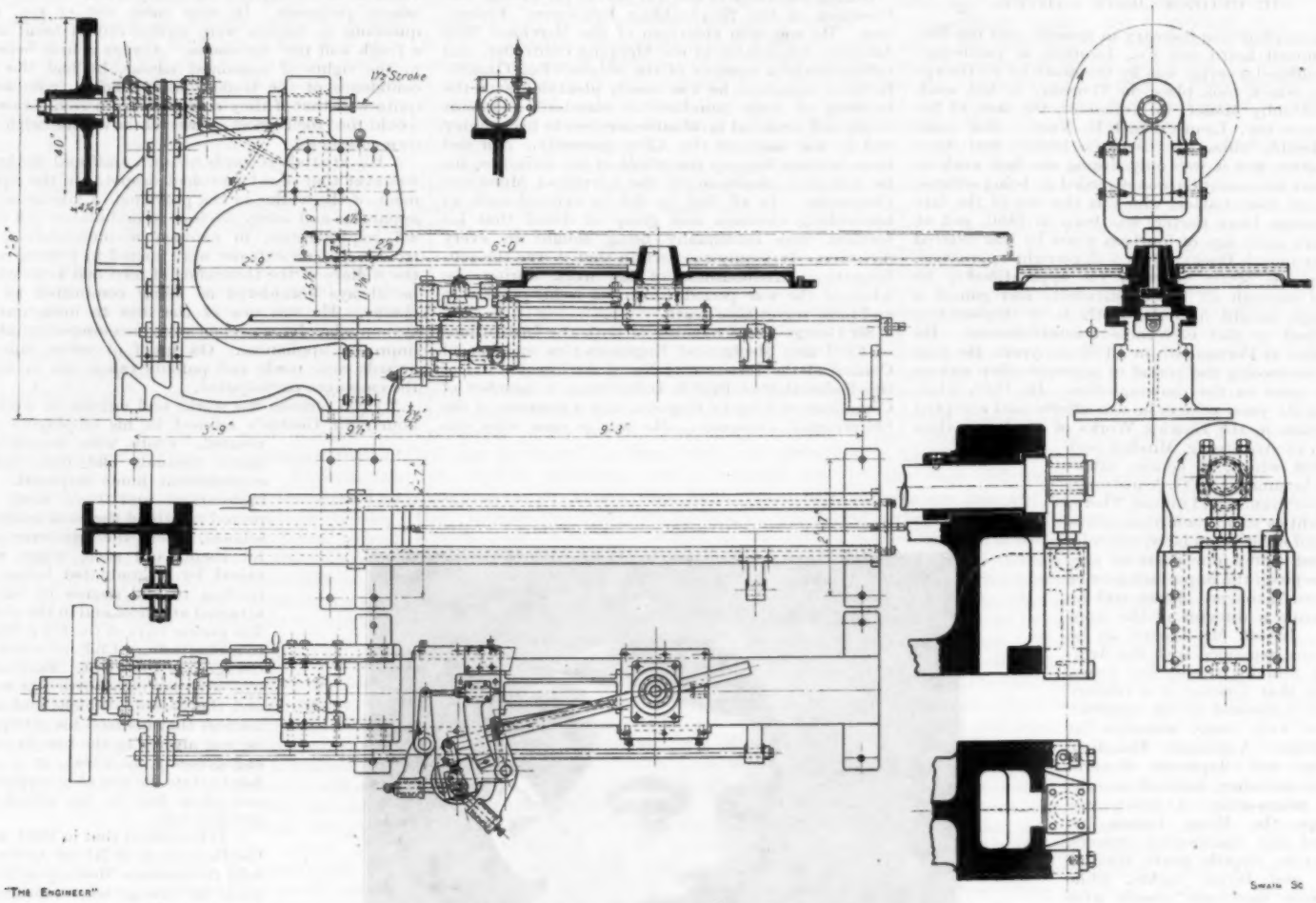
"It has been truly said that, as managing director of the huge Mersey-side shipbuilding establishment, Sir George never left one in any doubt as to who managed and directed. That was characteristic of the man. Outspokenness and direct dealing with individuals was almost an obsession with him. But when in the nature of things it became necessary to depute others to represent him during frequent, and sometimes prolonged, absences on urgent business, he always stood loyally by any decisions made on his behalf. It was all part of "playing the game," a phrase that was constantly on his lips.

"Sir George Carter was in many respects a great personality. He had his limitations, of course. He was not really such a hard case as he sometimes tried to make out. His apparent bluntness was largely bluff. He had a deep and abiding sympathy with the hard-working classes, and no one understood their mentality better than he did. Perhaps the keynote of his career is best expressed in a remark that he made shortly after taking up his important duties at Birkenhead. Some proposed welfare scheme was under consideration, and somebody quoted that well-known tag commencing 'I shall only pass this way once.' He immediately responded, and there is no doubt he meant every word, 'I believe it is everybody's duty to do his best for his fellow-men. For my part, I hope to leave the world a better place than I found it.'"

THE Rates Advisory Committee is entering upon the final determination of the proposed general railway classification of goods by merchandise trains which was published at the end of 1920, and has been the subject of discussion between the railway companies and the traders since that date. During those negotiations the commodities were divided into a number of groups for convenience of consideration, and the objections of the traders to the companies' proposals will be brought before the Committee under those groupings. The first group is being considered this week, and it is proposed that sittings shall be on Tuesday, Wednesday and Thursday in each week.

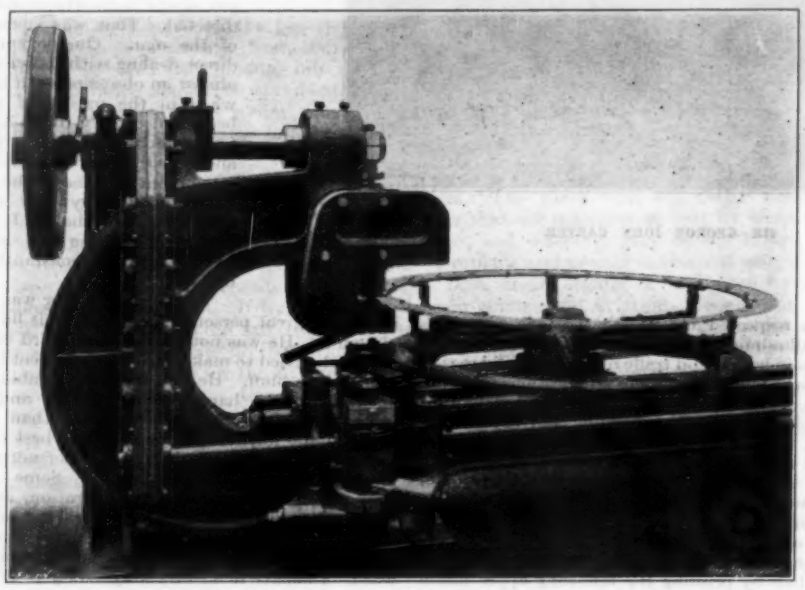
NOTCHING PRESS FOR ARMATURE PLATES AND SEGMENTS

TAYLOR AND CHALLEN, LIMITED, BIRMINGHAM, ENGINEERS



Notching Press for Armature Plates and Segments.

THE press illustrated herewith has recently been constructed by Taylor and Challen, Limited, of Birmingham, with the object of providing a machine whereby armature plates or segments thereof may be notched, internally or externally, in an accurate and continuous manner. The plates or segments, it will be gathered, are mounted on a gallery which is rotated by means of a dividing wheel so as to bring the work between a punch on the end of a reciprocating slide and a cutting die carried on a bracket. The bracket is of cast steel, and is bolted to the end of the frame. It is provided with two tongues which slip into two horizontal grooves cut one on each side of the frame head. The stress during the punching stroke is transmitted from the bracket to the frame through the tongues, the four bolts passing through the bracket being intended merely to hold it in its correct position and to provide means whereby it may be reversed in order to accommodate internal or external work.



NOTCHING PRESS FOR ARMATURE PLATES AND SEGMENTS

When the work is in the form of segmental portions the gallery is supplied continuously with blank segments without stopping the table or slide. In this way a complete circle of segments is notched in the same manner as if it were in one piece, with the result, it is claimed, that no inaccuracy arises in punching those notches which fall on the radial dividing lines between the segments.

The slide is driven by a ball-ended connecting-rod coupled to a crank of 1½in. stroke at the end of a belt-driven shaft. This shaft is equipped with a clutch and a band brake, which is automatically applied when the machine is stopped and released when it is started. A train of gear wheels within a casing carries power from the driving shaft down to a horizontal shaft, from which motion is imparted to the dividing wheel by means of a pawl. This pawl has associated with it a locking bolt whereby the dividing wheel and work are held fixed during each fall and rise of the notching tool. The pawl and bolt are both controlled by cams and springs. Their relative times of movement are so arranged that the bolt is in engagement with one notch of the dividing wheel before the feeding pawl is withdrawn from its notch. In this way, it is urged, all chance of the gallery overrunning its correct position is eliminated. The pawl and the other parts of the feeding gear are carried on a saddle which can be moved right back into the gap of the press frame in order that an increased size of dividing wheel may be accommodated. The saddle carrying the pivot on which the dividing wheel rotates can be adjusted along the bed by means of a screw to suit the diameter of the work.

The machine as illustrated is provided with a dividing wheel 6ft. in diameter. With this size of wheel work with notching circles ranging from 5ft. to 12ft. in diameter can be operated upon. With a dividing wheel 9ft. in diameter the largest notching circle diameter admitted is 18ft., while with a wheel 4ft. in diameter the minimum circle can be brought down to 3ft. In order to adapt the machine to accommodate work over 18ft. in diameter, the end of the bed is formed with machined flanges, to which an extension of the bed may be bolted. The gap of the frame is such that the machine can operate on internal work measuring up to 30in. from the centre line of the notches to the outside circumference. The average speed of working of the machine is 96 notches per minute.

It is to be particularly noticed that if it be desired to vary the number of notches to be formed on a circle of given diameter it is necessary to employ a different dividing wheel. In order to meet requirements in this direction the makers have installed at their works machinery for accurately cutting dividing wheels up to 12ft. in diameter.

Railway Electrification and Garratt Locomotives.

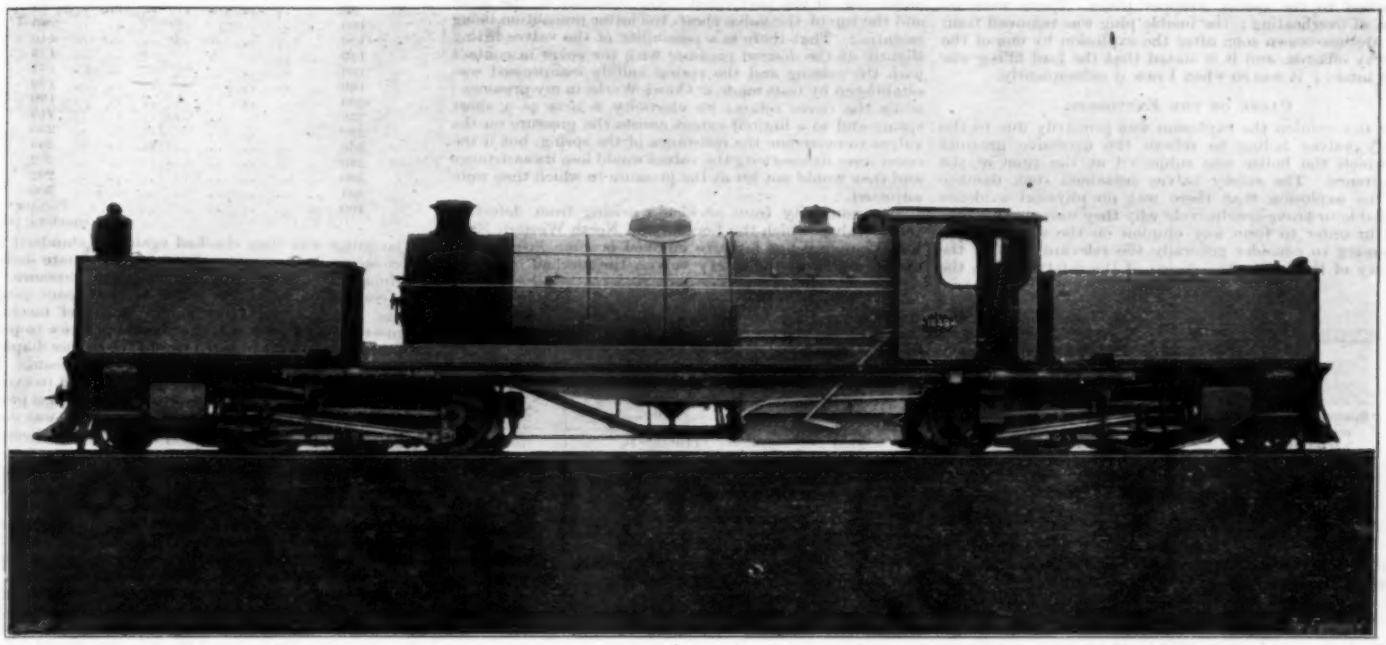
REFERRING to the very interesting abstract from a paper by Sir Vincent L. Raven, which appeared in our issue of December 23rd last, and the two diagrams illustrating respectively an electric freight locomotive of rating approximately 60,000 lb. tractive force and a proposed steam locomotive 0–8–2 type of equal power, Mr. E. A. Watson writes to us to say that Beyer, Peacock and Co., Limited, Manchester, built and sent out to South Africa last year, to the order of the South African Government Railways for their 3ft. 6in. gauge, a steam locomotive of the "Garratt" type working at a boiler pressure of 180 lb. per square inch, but which if arranged for 200 lb. per square inch—as proposed on the 0–8–2 diagram—would have about the same power, viz., 60,000 lb. at 85 per cent. boiler pressure.

A photograph of this "Garratt" type engine, which, as will be seen is of the 2–6–0, 0–6–2 wheel arrangement, is reproduced herewith. The maximum axle-load is about 18 tons, as compared with the abnormal axle-load of 33½ tons shown on the 0–8–2 diagram in the above-named article. The extreme height of this "Garratt" engine from rail to top of chimney is 12ft. 10in., thus coming well within the maximum for this country. The engine is working with great success on the 3ft. 6in. gauge, hauling heavy loads up gradients of 1 in 30 uncompensated, and round curves of 300ft. radius; and thus indicates what can be done with the "Garratt" type on the wider gauges of 4ft. 8½in. and upwards.

Mr. Watson informs us that designs of locomotives on

GARRATT LOCOMOTIVE FOR SOUTH AFRICA

BEYER, PEACOCK AND CO., LIMITED, MANCHESTER, ENGINEERS



the "Garratt" principle of quite normal dimensions and weights have been worked out by Beyer, Peacock and Co., Limited, for the 3ft. 6in. gauge having the 4–8–2, 2–8–4 wheel arrangement, and with a tractive force of about 72,000 lb. (at 75 per cent. boiler pressure) and a maximum axle-load of about 18½ tons, and the building of engines to these designs is contemplated. Until recent years electric locomotives certainly promised to provide greater tractive force then steam locomotives, but by making a comparison between Sir Vincent's electric locomotive and the "Garratt" type of steam engine it will be seen that similar results may be obtained for a given axle-load and within normal dimensions. From the foregoing it will be seen that finality has by no means been reached in the development of the steam locomotive.

The Buxton Locomotive Explosion.

As briefly stated in our last issue, Major G. L. Hall's report on the explosion of the boiler of a London and North-Western locomotive at Buxton on November 11th, 1921, was issued in the middle of last week. This report occupies forty-one foolscap pages, and includes four reproductions from photographs of the boiler *débris*, a plan of the marshalling yard at Buxton, where the explosion occurred, showing the position of the parts of the engine and boiler after the accident. An interesting fact brought out by this plan is that the fire-box wrapper plate was thrown forward 540ft., "N. by E." of the engine, and the fire-box back plate was hurled 670ft. almost dead ahead of the engine. The other parts were distributed locally, the engine frame and the remains of the boiler a little bit to the left and the fire-box crown a little bit to the right. Plate III. is a drawing of the boiler as new. As the question has been asked by a correspondent, we may say that the feed pipes are carried forward horizontal nearly up to the middle of the barrel and then turn down at an angle of 20 deg. or so, ending, of course, well below the water line in the final course of the barrel. Plate IV. is reproduced on page 190. It shows the safety valve; the detail on which Major Hall lays the blame for the explosion. A final drawing is a development of the boiler barrel plates showing the lines of fracture marked in red. It will be seen that with the exception of the drawing of the safety valve, and possibly the site plan which exhibits the position of the parts after the accident, the other plates are of relatively small consequence in seeking for a cause of the catastrophe whatever other interest may reside in them.

THE REPORT.

The essential part of the report as a whole is contained in the report made by Mr. H. Cranwell, of the Mercantile Marine Department of the Board of Trade. It we reproduce below almost in full. A few words about the history of the boiler must, however, first be given. It was built at Crewe in June, 1905, to work at 200 lb. pressure. As the average scrapping life of these boilers is eighteen years, it was near the end of its time. In January, 1907, it was given fairly extensive repairs, including the renewal of forty-six stays. Some time in 1908 it appears to have been repaired again, when "new barrel patches" were put along the barrel bottom, a new copper tube plate in two parts and a new steel tube plate were fitted, and 257 new copper stays were put in. In August, 1911, further repairs were carried out; the barrel was patched again along the bottom, the copper tube plate had to be attended to for cracks, and 193 stays were renewed. In the early part of 1914, and again two years later, important repairs were effected, including in the former year a new steel covering plate, new front plate, and new copper box. Then in June, 1918, the boiler was put on to the ill-fated engine No. 134, after it had been given a new crown plate, new top half copper tube plate, new steel tube plate, 201 new copper stays. Finally, in the present year it was sent to Beardmore's and underwent more heavy repairs, including two new half sides in fire-box, and the renewal of 439 copper stays. At this time the safety valves were refitted. After these repairs the boiler was tested at 205 lb. hydraulic and 200 lb. steam. The engine was one of eighteen sent to Beardmore's, of which twelve went to Parkhead and six to Dalmuir. After leaving Beardmore's it had run altogether 2600 miles before the accident occurred.

THE EXPLOSION

The engine was taken over by the shed driver with the steam gauge reading 120 lb., and was handed over to the train driver at 11.55 with the steam still at that pressure. At 12.25 it was taken out of the shed and coupled to a goods train. At 12.45 it was started, but had made no more than about four beats when the boiler burst. The fire-hole door was open at the time, as the stoker had only just finished firing up. A head-shunter saw the smoke-box door fly open and fire come out. The valves had not been blowing all this time.

The steam gauge of the engine had been reported several times as defective, "reading too high," "going all round," and so on, and constant trouble had been experienced with the injectors, which, it is significant, will not work at high pressures. There is ample evidence that the valves blew freely at 200 lb. during August, September, and the greater part of October.

MR. CRANWELL'S REPORT.

NATURE OF THE EXPLOSION.

The explosion was of a very violent character; the fire-box crown was forced down bodily into the fire-box, and the sudden admission of steam into the fire-box through the large opening resulted in the complete destruction of the boiler. The most serious damage to the locomotive below the frames occurred directly under the fire-box; the cylinders and valve gear and the tender sustained very little damage. The right-hand trailing wheel was driven off its axle, and was projected about 17 yards to the right; the left-hand trailing wheel was started from the axle, the wheel centre was cracked, and the wheel and axle were displaced to the left; the back ends of the engine frames were bent outwards. The fire-box foundation ring fractured at each corner; the casing wrapper plate to which the fire-box side plates and a portion of the right-hand side of the throat plate remain attached was ripped off, opened out practically flat and projected about 172 yards. The casing end (front) plate with fire-box back plate attached, being released initially from the bottom, swung upwards and came to rest at a distance of 222 yards from the engine. The fire-box crown plate with the girders attached was found completely separated from the casing wrapper plate. The flanged portion of the upper part of the fire-box tube plate was parted from the fire-box crown and side plates, and also from the part of the tube plate into which the tubes were expanded. The ends of most of the tubes projected slightly through the tube plate, which was distorted, and the palm stays were broken.

The back ring of barrel plating to which the throat plate remained attached fractured diagonally through the solid plate from the top of the right-hand side of the throat plate to about the centre of the line of rivets which secured the longitudinal stay bracket; the fracture followed the line of rivets circumferentially and extended into the front part of the longitudinal seam. This ring of plating opened out, and in doing so buckled the throat plate and tore the middle ring of barrel plating along the circumferential seam. The lower part of the copper tube plate was severely damaged and was found in three pieces, of which one only remained attached to the throat plate. It was apparent, however, that the failure at this part was subsequent to that of the fire-box crown; there were distinct marks on the copper plate which corresponded with the feet of the crown girders, and the left-hand portion of the plate was pierced and ripped off the stays by one of the feet of the girders. The middle part of the copper plate which remained attached to the throat plate by four stays near the bottom had evidently been torn from the other stays after the initial failure of the crown, and the right-hand portion of the copper plate was apparently forced from the stays by the distortion of the throat plate at that part.

The middle ring of barrel plating fractured longitudinally through the solid plate, and in opening out separated from the front ring along the circumferential seam. The latter ring of plating was practically undamaged except at the circumferential seam. The smoke-box tube plate was slightly distorted; some of the tubes were set forward through the plate and a few were pulled out.

Fire-box failures are usually associated with the violent displacement of the whole boiler to a considerable distance, and in such cases the barrel generally remains intact. In the present case, however, the bulk of the body of the boiler was displaced a short distance only and the barrel fractured; but I am of the opinion that the explosion originated in the fire-box for the following reasons:—The only part of the copper fire-box which was wholly detached from its supporting casing plate was the crown. It is clear from the evidence afforded by the fragments that the crown suspension system failed, and that the abutments of the girders were not able to withstand the load then imposed on them; the flange of the tube plate on which the front ends of the girders rested was torn from the body of the tube plate, and the top of the fire-box back plate on which the back ends of the girders were supported was crushed in between the two upper rows of stays and fractured along the line of the top row of stays. The two upper rows of stays were badly bent and the fire-box back plate bore the marks of the girder ends below the line of fracture. These conditions could not arise from an initial barrel failure. The longitudinal stays were broken, and from the appearance of the ends attached to the bracket, the stays appeared to have been pulled downwards; it will be observed from the design of the boiler that this is probably what would happen if the crown and girders came down first. It is of some significance that the barrel fractured diagonally and longitudinally through the strongest part of the solid plates where there was very little reduction from the original thickness of the plate. The barrel had been fitted with a patch along the bottom on account of pitting at that part; the longitudinal pitch of the rivets which secured the patch to the barrel was 3in.; the percentage strength of the plate along the line of rivets was, therefore, considerably below that of the longitudinal seam, and if the barrel had failed before the fire-box it would most probably have done so along the line of least resistance, i.e., along the line of closely spaced patch rivets. An examination of the fractured edges of the barrel plating showed that the plates had failed by ripping; there was very little local reduction in thickness, and the burred edges characteristic of ripping were very pronounced.

The results of tests of specimens cut from the fractured plates in the direction of the length of the plates were as in the tale bon the next page.

The extensions were rather low, and one bend test was not satisfactory, but it should be noted that the plates had been subjected to severe treatment by being bent to the form of the barrel and subsequently straightened.

Furthermore, the statement of the head shunter at Buxton that "he saw the smoke-box door fly open and fire come out" would suggest fire-box failure.

The positions of the casing end and wrapper plates after the explosion indicate that the fire-box end of the boiler was elevated at the time the parts were released, and if the explosion had been less violent and the fire-box had not been so completely shattered, it is probable that the boiler would have been projected a considerable distance. It is also probable that the pressure in the boiler at the time of the explosion approximated to the bursting pressure of the barrel, and the additional stresses

set up in the barrel by the pressure of steam in the fire-box caused the barrel to fracture in the manner described. The water-gauge fittings, injectors and steam gauge were broken and scattered by the explosion; the safety valve lever was bent and the back safety valve was found some distance from the valve chest, which remained attached to the casing wrapper plate. There were no signs of overheating; the fusible plug was removed from the fire-box crown soon after the explosion by one of the railway officials, and it is stated that the lead filling was then intact; it was so when I saw it subsequently.

CAUSE OF THE EXPLOSION.

In my opinion the explosion was primarily due to the safety valves failing to relieve the excessive pressure to which the boiler was subjected at the time of the occurrence. The safety valves sustained such damage by the explosion that there was no physical evidence available to prove conclusively why they were inoperative, and in order to form any opinion on the subject, it is necessary to consider generally the relevant part of the history of the boiler, the design of the safety valves, the methods of their manufacture and repair, and the possibilities of over-pressure in the boiler.

Tests of Boiler Plates.

		Area in square inches.	Ultimate tensile strength in tons per square inch.	Ultimate elongation in 8in. per cent.	Angle through which sample bent without fracture.	Fracture.
X	Specimens from middle ring of barrel plating.	1.26	30.36	20.0	180 deg.	Normal
		1.26	31.35	21.0	110 deg. B.	Normal
XX	Specimens from back ring of barrel plating.	1.30	32.50	18.0	—	Normal
		1.30	32.11	17.0	180 deg.	Normal

GENERAL REMARKS.

The boiler was built in 1905 by the London and North-Western Railway Company at their works at Crewe. The necessary repairs were carried out by the railway company until October, 1920, when locomotive No. 134, to which the boiler was then fitted, was sent to Messrs. Beardmore's Works, Parkhead, for extensive repairs; these were completed and the locomotive was passed into service in July, 1921.

The parts repaired by Messrs. Beardmore which were most directly connected with the explosion were the fire-box, including the means of staying, and the safety valves. The copper stays appeared to have been well fitted, and with regard to the replacement of the fire-box crown suspension system, it is apparent from the evidence that the railway company's inspector realised the importance of accurate adjustment, and that his instructions to the repairers were efficiently carried out. On completion of the repairs, the boiler was tested by hydraulic pressure to 205 lb. per square inch, and by steam to 200 lb. per square inch, and it is stated that during the hydraulic test the fire-box crown was not unduly deflected. The hydraulic test to only 5 lb. per square inch in excess of the working pressure cannot be regarded as anything better than a caulking test. I understand, however, that in future such boilers are to be tested hydraulically to about 1½ times the working pressure.

The design of the duplex safety valve is shown herewith. The safety valve chest was made of cast iron and was bolted to a steel throat piece riveted to the casing wrapper plate. The brass valve seats were fitted to the top of the columns and each bush was secured in position by a brass set pin $^{5}/_{16}$in. in diameter screwed into the chest and sent. The valves were made of brass and were formed with three webs; the conical recess at the top of the valve was machined to ensure that the pressure of the spring was applied centrally. The spring, compression bolt, &c., were contained in the enclosed space between the upper part of the columns. The safety valve lever was of the ordinary Ramsbottom type; the front bearing centre was attached to the lever by a pin, the back bearing centre was forged on the body of the lever; the provision of the loose front centre allowed the bearing points to adjust themselves to the valves. Between the centres a projection was formed on the under side of the lever from which was suspended an inverted U link, which passed through suitable holes in the mushroom head of the compression bolt and supported the spring. The amount of compression on the spring was limited by a brass distance piece or tube placed between the head of the compression bolt and the bottom of the spring recess. The body of the compression bolt was ¾in. square in section; the end was ⅝in. in diameter screwed with a Whitworth thread. The bolt fitted through a square hole at the bottom of the spring chamber and was furnished with a nut for adjusting the compression of the spring and a lock nut; the adjusting nut and the bearing face of the casing were machine faced to ensure correct alignment of the parts. A perforated brass cover in halves was riveted to the lever above the point of suspension of the spring, and ventilation holes fitted with perforated brass plates were provided near the bottom of the spring recess. The space below the spring chamber and between the lower part of the columns in which the compression nuts were situated was closed by plates secured by two bolts; a piece of copper wire was threaded through a hole in the end of one of the bolts, and the ends of the wire were joined by a lead seal. The arrangement was such that it was impossible to interfere with the compression nuts without destroying the seal.

The practice at Crewe Works was to rough machine the webs of safety valves to a standard, and to form the valve face at an angle of 135 deg. with the webs. After the seats were driven into the columns and secured in position, the valves were fitted to the bushes by filing the webs; the valve chest was then bolted to a steam-heated saddle on which the final adjustment of the spring was made, and the valves were ground in after they and the whole of the valve chest were thoroughly heated. The actual amount of clearance between the valve webs and the bushes was not definitely specified, but was left to the discretion of the foreman in charge. The valves when new did not project through the seats, and the ends of the webs were generally bevelled by filing. In adjusting the valves, the distance piece was made about $^{1}/_{32}$in. shorter than the distance between the head of the compression bolt and the bottom of the spring chamber, and particular care was taken to allow sufficient clearance between the under side of the perforated cover attached to the lever and the top of the valve chest, the latter precaution being essential. That there is a possibility of the valves lifting slightly at the desired pressure with the cover in contact with the casting and the spring unduly compressed was established by tests made at Crewe Works in my presence; while the cover retains its elasticity it acts as a short spring and to a limited extent assists the pressure on the valves to overcome the resistance of the spring, but if the cover loses its elasticity the valves would lose its assistance and they would not lift at the pressure to which they were adjusted.

The immunity from accidents arising from defective safety valves which the London and North Western Railway Company has hitherto enjoyed is some justification of the design of the safety valves, the method of manufacture, and the company's confidence in the ability of the men to whom the assemblage and adjustment of the safety valves has been entrusted.

The repairs to the safety valves carried out by Messrs. Beardmore included machining and re-grinding the faces of the valves and seats and fitting a new loose centre to the lever. It was stated that the valves were suitably marked when dis-assembled, and after being machined the valves were ground into their respective seats; during the latter process the railway company's general practice of steam heating the valve chest and valves was not as a rule followed. It was also stated that it was not necessary to file the webs of the valves, and that after assembly the valves were adjusted, the front one to lift at 200 lb. per square inch and the back one to a few pounds heavier, to the instructions of the railway company's inspector.

After leaving Messrs. Beardmore's Works, the locomotive had run only 2600 miles before the explosion occurred. There are no less than four entries against the steam gauge; driver Allen reported on September 23rd, "Steam gauge goes all round"; driver Booth reported on October 22nd, "Steam gauge changing"; driver Geldard also reported on the same day, "Steam gauge changing," and on the day before the explosion driver Winstanley, who handed the engine over to shed foreman Oldfield at Buxton, reported, "Steam gauge wants changing—registers 300 lb." It appears that the steam gauge was changed at Stockport on November 9th, and at Buxton on November 10th. As the steam gauge which was connected to the upper part of the water gauge was not capable of being shut off from the boiler, it could not be changed while any pressure remained in the boiler. The sheds were not equipped with means for checking gauges reported to be defective, but such gauges were sent to Crewe Works for adjustment. Apparently reports against steam gauges were not uncommon, while adverse reports of safety valves were practically unknown, and it does not appear to have occurred to anyone concerned, with the possible exception of driver Winstanley, that there was a possibility of the steam gauge being correct and the safety valves defective. Winstanley's remark to the shed foreman, when handing over the engine at Buxton, to the effect that the safety valves would not blow off, does not appear to have been very convincing. It was not possible to trace the gauge that was changed at Stockport, but the one that was reported defective on arrival at Buxton, and was replaced before the explosion, was taken charge of by one of the company's officials and was tested in my presence at Crewe Works. It was identified at the inquiry by driver Winstanley as the one which he had reported at Buxton as registering 300 lb.

The comparative readings of this gauge and a standard gauge during the application of an increasing hydraulic pressure were as follows:—

Standard gauge.	Gauge from engine 134.
20	—
40	12
60	47
80	65
100	85
120	110
140	135
160	152
180	170
200	190
220	215
240	235
260	255
280	272
300	292
304	300
400	Pointer touching peg

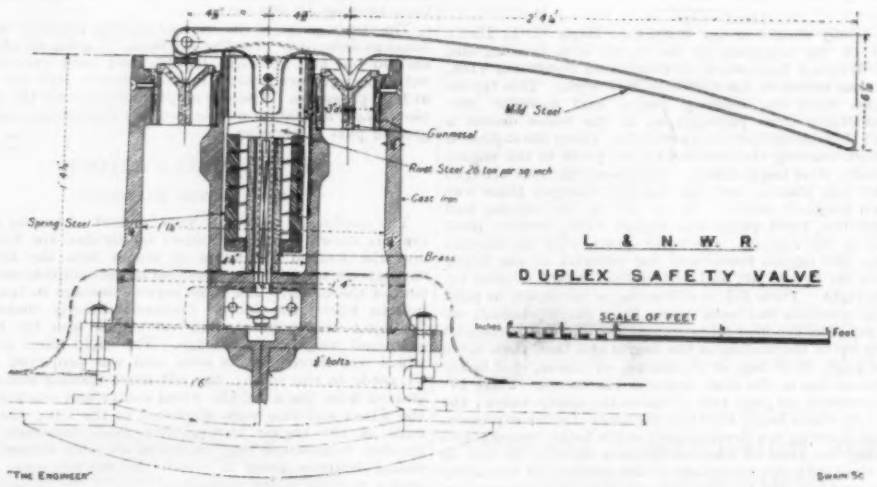
The gauge was then checked against a standard gauge under steam at a pressure of 200 lb. per square inch, and was found to be practically correct at that pressure. The pipe connection from the boiler to the steam gauge of engine 134 was not found; but the chief mechanical engineer stated that it was the general practice to provide a suitable bend in the pipe to prevent the rubber diaphragm and spring becoming overheated by the steam. There can be no doubt that the boiler was subjected to excessive pressure on the day before the explosion, and it is probable that the gauge previously reported defective was correct, and that the boiler had been repeatedly pressed considerably above the designed working pressure.

From the driver's replies to a circular letter it appears that the first occasion on which the safety valves did not lift at the ordinary working pressure was September 14th, and from October 20th the safety valves apparently became practically inoperative; there are also three entries in the shed books from October 5th to 22nd that the safety valve cover joint was blowing, and leaks were reported to have developed in the fire-box at the joint of upper and lower half sides on October 14th and 15th; these are all indicative of excessive pressure. A number of reports were made that "the injectors would not work when high in steam," but reports of this nature appear to be made frequently in respect of engines working at a pressure of 200 lb. per square inch.

On examining the wreckage after the explosion, it was apparent that the boiler had failed through over-pressure, and that the initial failure occurred at the fire-box crown-suspension system, which was unable to support the excessive load on the crown; and it is thought that the surging of the water in the boiler towards the fire-box when the engine started gave the slight additional load necessary to start the destruction.

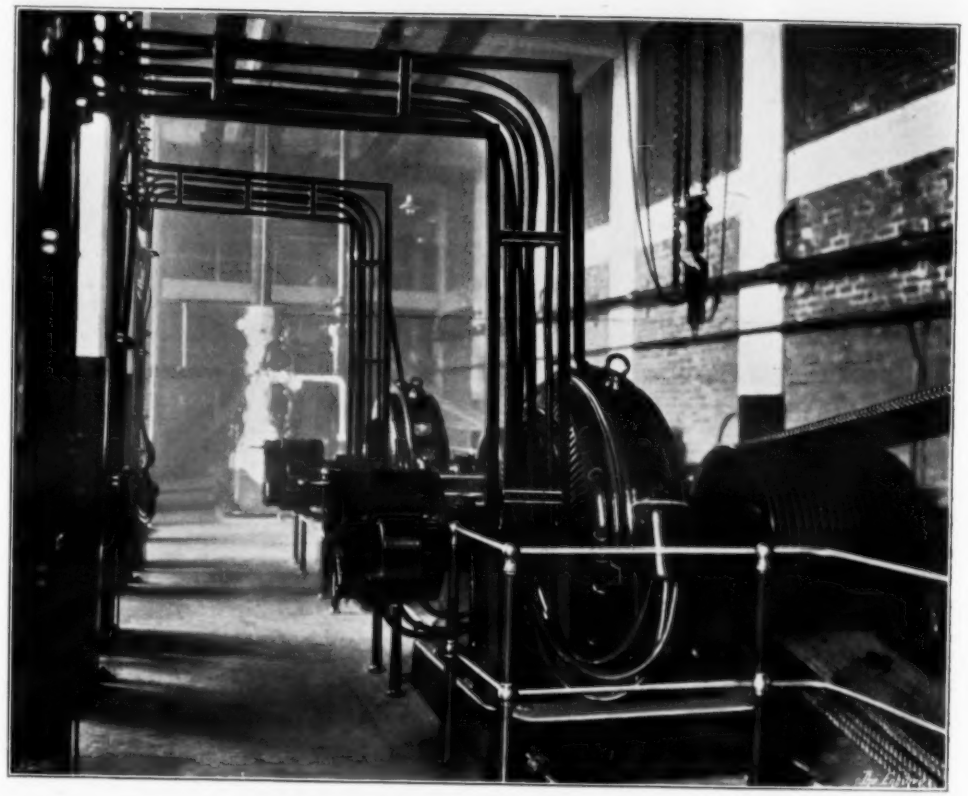
On examining the safety valves after the explosion, I found that the back end of the lever had been bent upwards and to the right; the back centre of the lever had been displaced from its bearing on the back valve and was resting on the top of the valve chest in such a position that the valve which was found near the engine could be replaced in its seat; from the appearance of the valve it was apparent that the lever had been bent upwards before the valve was displaced. The loose bearing centre at the front end of the lever was resting lightly on the top of its valve, and neither the centre nor the valve was jammed; the lead seal was missing, but a portion of the copper wire remained attached to the sealing bolt.

I witnessed the dismantling of the safety valves at Crewe Works, and apparently the parts had been correctly assembled at Messrs. Beardmore's Works. It is unfortunate that the bending of the lever destroyed all physical evidence in regard to the clearance between the perforated brass cover attached to the lever and the valve chest and the amount of compression on the spring; the latter depends not only on the position of the head of the compression bolt, but on the relative positions of the bearing centres of the lever and the point of suspension of the spring. The compression bolt was found to be bent $^{5}/_{32}$in. in the direction of the lever, the brass distance piece bore the impression of the inverted U link at the top, and the perforated cap attached to the lever was cracked and was bearing on the top of the chest; it is possible that all these irregularities were caused by the bending of the lever. The width of the bearing surface of the valve seating was ¼in., and the angle between the webs and the valve faces was 150 deg. in each case. The front and back valves projected $^{5}/_{16}$in. and $^{3}/_{16}$in. through their respective bushes; the ends of the webs were not bevelled

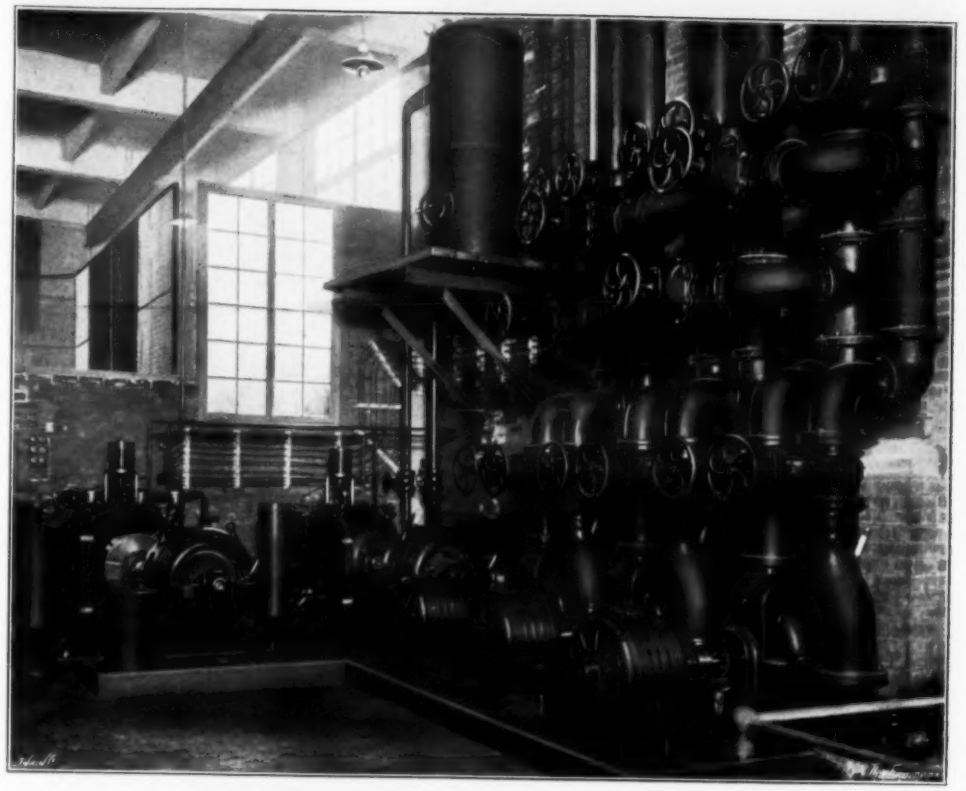


ICE FACTORY AT GRIMSBY

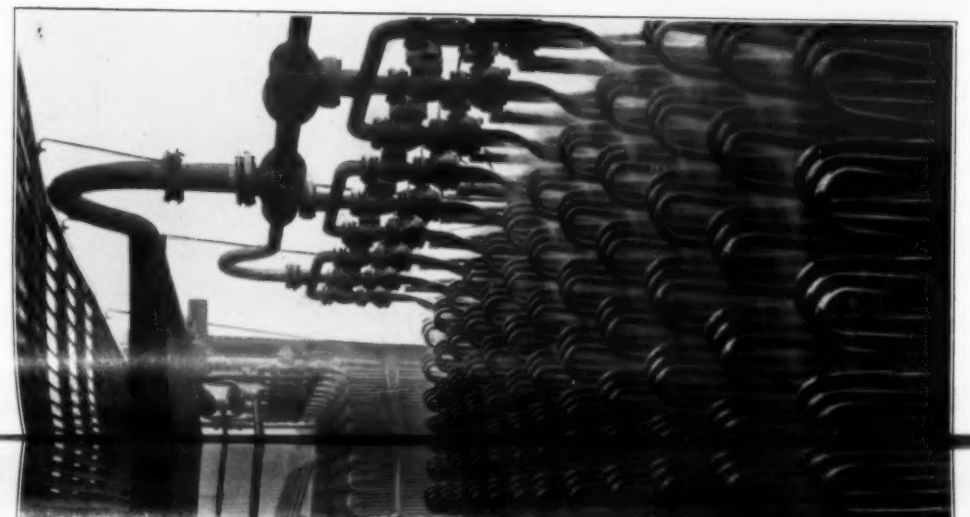
THE PLUPERFECT REFRIGERATION COMPANY, LIMITED, MANCHESTER, ENGINEERS



300-H.P. MOTORS DRIVING THE AMMONIA COMPRESSORS

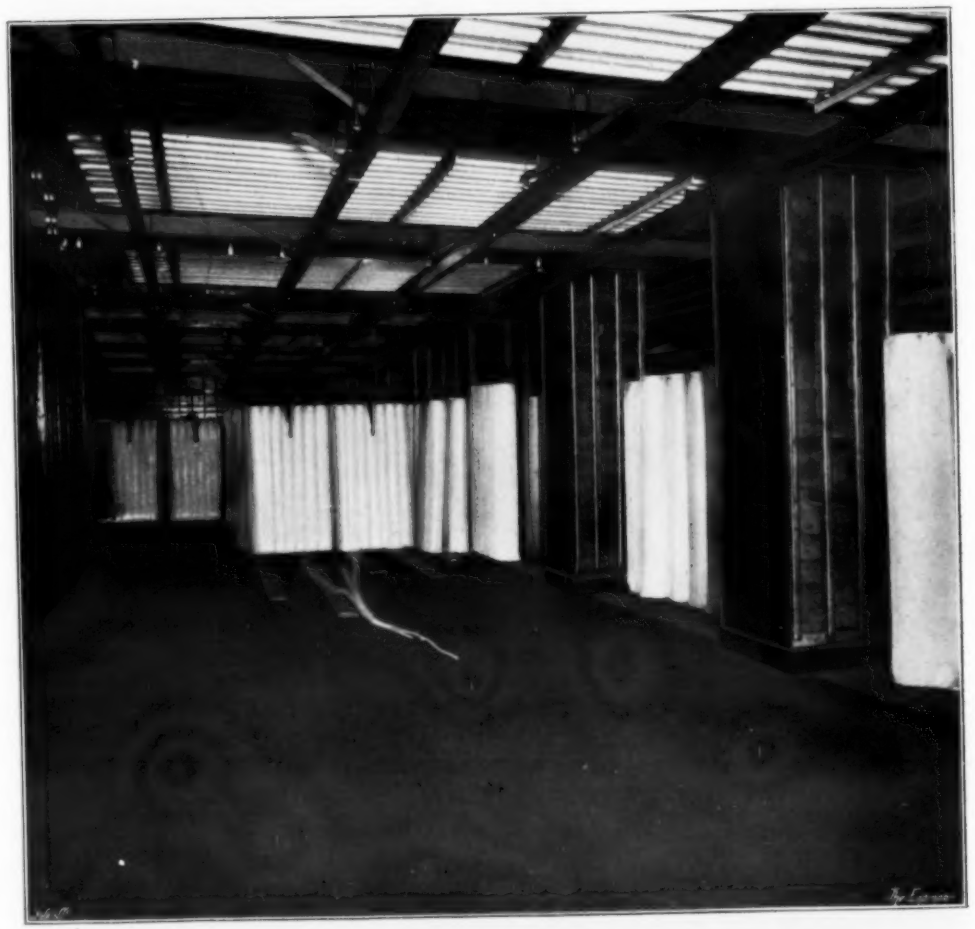


MOTOR-DRIVEN BRINE CIRCULATING PUMPS AND AIR COMPRESSORS

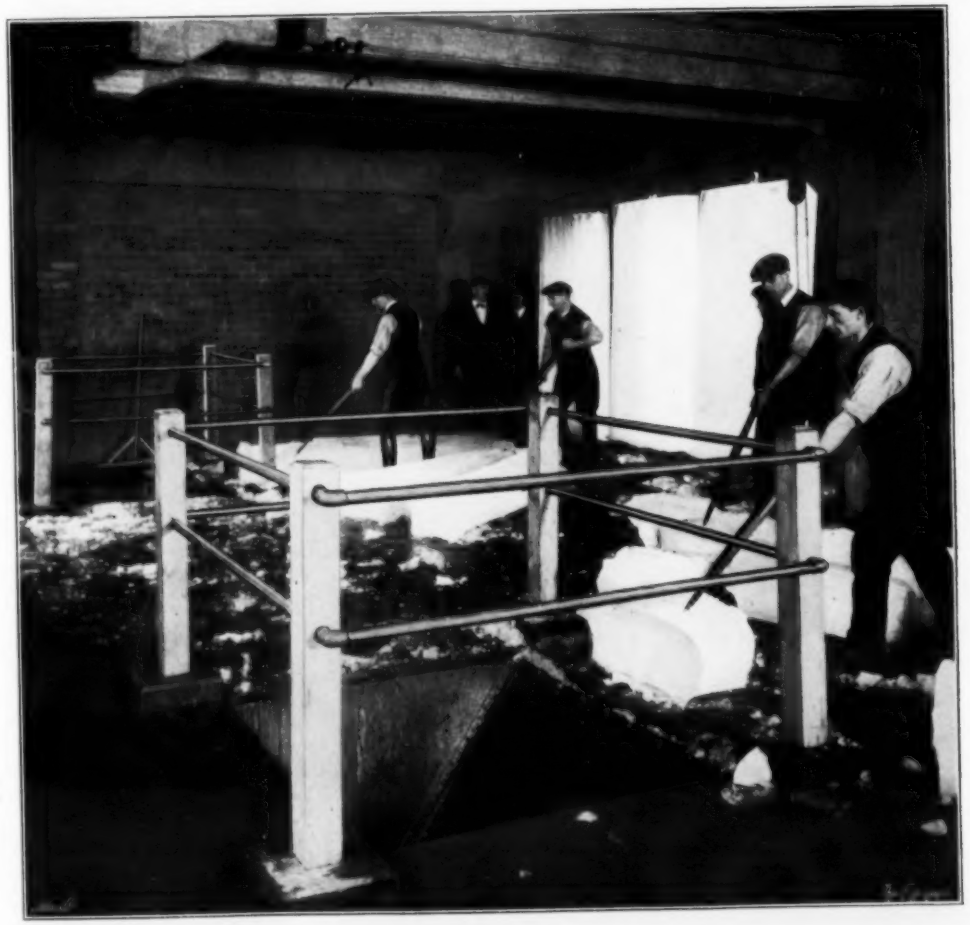


AMMONIA CONDENSERS ON THE ROOF OF THE FACTORY

ICE TANKS WITH COVERS REMOVED SHOWING BLOCKS BEING FROZEN



INSULATED STORE FOR ICE BLOCKS, SHOWING OVERHEAD CONVEYING RUNWAYS



FEEDING BROKEN ICE BLOCKS INTO THE CRUSHERS

and the marks of the three webs were visible in each bush. The valve seats were not truly circular and the webs of the valves were not uniform in diameter, and in order to determine the minimum clearance between the valve webs and their respective bushes, parallel plug gauges to fit the bushes at their smallest part and parallel ring gauges to just pass over the full length of the webs were made.

The diameters of these gauges were as follows :—

Front seat ..	2.9715in.	Back seat ..	2.9695in.
Front valve ..	2.962in.	Back valve ..	2.9575in.

The minimum clearance was therefore .0095in. for the front valve and .012in. for the back valve when the parts were cold ; this amount of clearance is less than should be allowed.

As stated above, the actual amount of compression on the safety valve spring before the explosion could not be ascertained, and in order to see whether there was sufficient clearance between the coils of the spring when adjusted for a working pressure of 200 lb. per square inch on the valves, the sides of the safety valve chest between the columns were cut away to expose the spring and the valves were assembled with a new lever and adjusted to lift at a hydraulic pressure of 200 lb. per square inch ; it was considered unwise to subject the valve chest to steam pressure. The total compression of the spring in this condition was $^{13}/_{16}$in. ; the total clearance between the coils was $^{13}/_{32}$in. ; the distance piece was free between the legs of the U link, and the short bent ends of the link were not visibly deflected.

A suggestion had been made that the alteration of the angle of the valve face from the 135 deg. to 150 deg. would cause the valve to become wedged into the seating, but I was unable to obtain this result even when the valves were excessively loaded. In the case of ordinary spring-loaded safety valves, the most desirable angle between the webs and the valve face would appear to be 90 deg. in order to obtain the maximum area of valve opening for a definite lift and a minimum normal pressure between the faces of the valve and seat ; the alteration in the angle of the valve from 135 deg. to 150 deg. would reduce the effective area of valve opening for small lifts and would increase the normal pressure between the faces.

The valve seats appeared to be tight in the columns when sounded with a hammer, and there is no doubt whatever that they were firmly secured in position, because on attempting to draw them by means of plates and a bolt 1in. in diameter, it was found impossible to move the bushes by tightening the nut by hand with a spanner 14in. long, and it was not until the end of the spanner had been hammered that the seats were started.

When the seats were finally drawn it was seen that the set pins had been sheared in the process and that they had been well fitted. The protrusion of the webs through the bushes was a most undesirable feature, as there was the possibility of a deposit forming on the ends of the webs which would tend to prevent the valves lifting. The safety valve chest was not provided with lagging.

It is possible that there may have been several causes operating to prevent the safety valves functioning, but, in my opinion, the main contributory cause was the small amount of clearance between the valve webs and the seats when cold ; the difference in the expansion of the cast iron chest and the brass valves and seats and the probable distortion of the latter would reduce this clearance under steam to a dangerously small amount, particularly when the temperature of the atmosphere was low. If the valves were not free to lift owing to the webs expanding and binding in the bushes when the boiler pressure was 200 lb. per square inch, any increase in the pressure and corresponding temperature of the steam would tend to bind the valves more firmly. The safety valve seats were renewed in 1914, and the valves apparently worked satisfactorily before the engine was repaired at Parkhead, and during warm weather subsequently, but the conditions before and after repair were not identical, because the alteration to the angle of the valves and seatings caused the valves to be lowered a considerable amount in the bushes. It is, moreover, a most significant fact that the drivers' reports against the steam gauges were made when cold weather was experienced.

The chief mechanical engineer acted with commendable promptitude in recalling from service all safety valves of engines of this class repaired by Messrs. Beardmore ; From the evidence given at the inquiry, it appears that some of these valves were not satisfactory when tested and disassembled at Crewe Works.

A boiler similar to the one from which the explosion occurred was tested to destruction at Crewe Works by hydraulic pressure. The test was terminated by the breaking of a defective roofing bar bolt when the pressure was 600 lb. per square inch, but there were no signs of barrel weakness at that pressure.

CONCLUSION.

Major Hall reports in conclusion : I agree with the opinions expressed and the conclusions arrived at by Mr. Cranwell, both in regard to the nature and cause of the accident, namely, that the explosion, which was due to over-pressure, originated in the fire-box crown ; that there were probably several contributory causes which prevented the safety valves from relieving the excess pressure, the main contributory cause being the small amount of clearance between the valve webs and the seats when cold. These conclusions were formed only after full discussion between us, and careful consideration of every possible alternative. Certain other suggested causes have been submitted both by letter and in the public Press, and due attention has been paid to these. A suggestion has also been current that the explosion may have been due to the presence of an explosive in the fire. Not only, however, is there a total absence of evidence to support this theory, but the nature of the damage and the course of the explosion are both decidedly at variance with it.

The case is a remarkable one, and its investigation has presented considerable difficulty, chiefly in respect of determining, first, whether excess pressure could be proved ; and, secondly, how such excess pressure could have arisen. The reasons for arriving at both conclusions have been dealt with in detail. The difficulty in respect of the latter point was greatly increased by the obvious fact that the dividing line between freedom and jamming of these valves was very fine, and that a combination of several factors, of which the very low temperature of the night in question was probably the last, was required to produce a dangerous condition.

It is clearly impossible, in a case of this kind, to arrive at a conclusion as to the correctness of which there is no element of doubt, but in the light of the evidence submitted, and the various tests and measurements carried out, there is, in my opinion, no other solution which would so adequately cover all the facts of the case as that advanced.

(2) There is nothing in the evidence dealing with the boiler repair work carried out by Messrs. Beardmore's to suggest either defective workmanship or inadequate supervision. On the contrary, every care appears to have been taken to turn out a job which would be as satisfactory to the railway company as if it had been done in their own works. It was certainly unfortunate that the valves and seats were faced to the incorrect angle, which resulted in their being lowered in the bushes ; but although this was probably one of several contributory causes of the eventual explosion, it would not in itself necessarily have led to any danger. There is, in fact, proof not only that the valves lifted correctly on test, but they continued to do so for some months in service.

However, whatever the cause of the jamming of the valves, their condition would have been suspected and the accident almost certainly prevented if either some system had been in force for testing in the sheds a newly fitted gauge for accuracy, or driver Winstanley had followed up what, I am sure, were his suspicions, and reported the valves untrustworthy ; or, finally, if Holmes or his fireman had noticed the gauge pass the working pressure. In view of the proved reliability of these valves over so many years, Winstanley no doubt found it difficult to believe that his suspicions could be well founded ; a view likely, I think, to have been taken by every driver giving evidence, who would, there is little doubt, naturally assume the gauge and not the valve to be at fault : adverse reports on the former being comparatively common and on the latter unknown. This fact no doubt also accounts for the absence of test on these gauges when they are fitted to an engine at the sheds.

(3) My general conclusion in this very serious case is that so many factors, some of them not necessarily constituting an element of danger in themselves, contributed to the result, that no responsibility can fairly, in the circumstances, be assigned to any individual.

I have two recommendations to make in this case, to both of which I understand the company is prepared to agree, or has already given effect.

(1) That the final machining or fitting of the safety valve bushes should be done after they are driven into their seats, and that the valve webs should be finished to a standard and known clearance in the bushes.

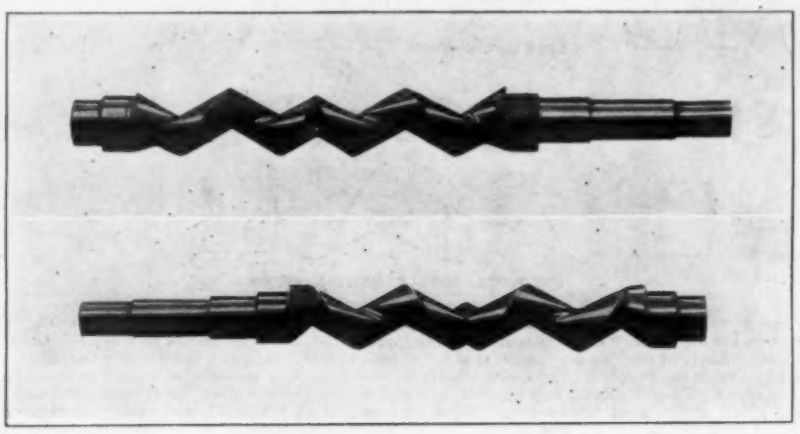
(2) That whenever a steam pressure gauge is changed at the running sheds, the newly fitted gauge should be tested against the safety valve of the engine. It would facilitate this operation if a cock were fitted on the gauge pipe, to obviate the necessity of letting down the steam in the boiler.

PROPOSED MOVING PLATFORM FOR PARIS.

THE authorities of the City of Paris have given notice of their intention to hold a competition for the design of a moving platform for the conveyance of foot passengers. In addition to putting forward proposals for the design of the platform, competitors will be required to make suggestions on the practical working of their scheme and to discuss such matters as stations, lifts, escalators, access to the public streets, junctions with existing underground lines in Paris. Three prizes with values of 100,000f., 50,000f., and 30,000f. respectively will be placed at the disposal of the judges, who will be at liberty to award them intact or in part at their discretion. The projects to which the prizes are awarded will remain the property of their authors, but the City of Paris does not undertake to have them put into effect either by the author or authors, or itself. On the other hand, if the City, after having awarded a prize to a design, should propose to install it, and if an amicable understanding cannot be arrived at with the inventor, the entire design may be acquired by the City on payment of forfeiture of 500,000f., or if less than the whole design be adopted, then by the payment of a lesser sum to be settled by arbitration. The competition is open to the world, but foreigners will have to subscribe to a certain agreement, the terms of which have not yet been published, before they can enter for it. It will close on September 20th next. It is stipulated that the fastest moving member of the platform must attain a speed of 15 kilometres—nearly 9¼ miles—an hour. Full particulars as to how to enter for the competition may be obtained on application to La Direction des Travaux de Paris, 98, Quai de la Rapée, Paris XII^{e}, but on technical points, would-be entrants should send their enquiries to La Service Technique du Metropolitain, 48, rue de Rivoli, Paris.

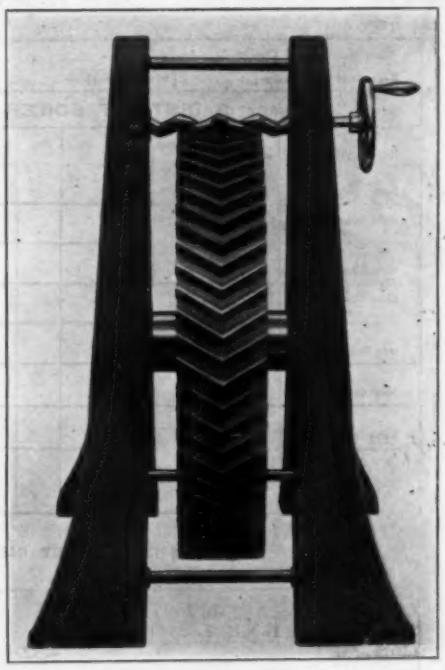
A One-tooth Helical Pinion.

THE double helical gearing illustrated herewith, having a pinion with but one tooth, is not only of great interest to the student and of much value for experimental work, but, according to the makers, the Power Plant Company, Limited, of West Drayton, is also of wide practical utility. The particular example illustrated is, we understand, shortly to be deposited in the South Kensington Museum, while a similar one, as soon as convenient, will be put into actual service by the company. Under a power test over a considerable time the gearing transmitted 10 horse-power at a pinion speed of 1000 revolutions per minute without showing any signs of wear. With the pinion as the driver the makers believe that the efficiency is as high as that of any other double helical gearing, that is to say, that it is probably between 97 and 98½ per cent. In this connection it may be remarked that the gearing is said to work satisfactorily with the wheel as the driver. As for its practical utility, it is pointed out that it is much more compact, more efficient and cheaper to produce than double-reduction gearing of the same ratio.



A ONE-TOOTH DOUBLE HELICAL PINION

The production of a one-tooth double helical pinion such as that illustrated has only recently become possible.



ONE-TOOTH PINION AND WHEEL

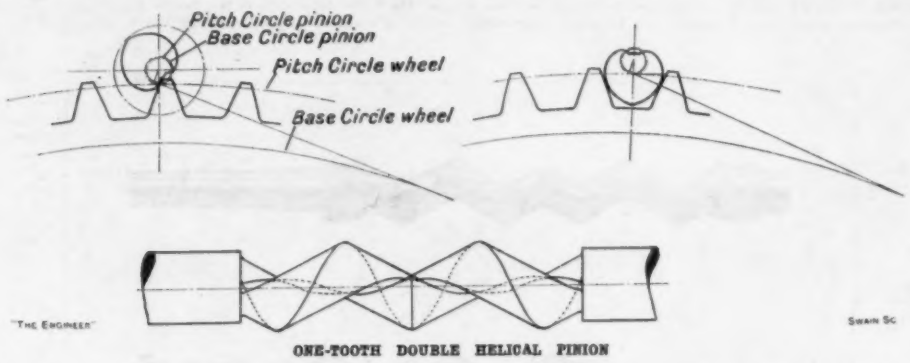
The example shown was made on a Sykes No. 4 patented generating machine with standard equipment and cutters. The same machine and the same cutters were used for producing the wheel. The teeth of both the pinion and the wheel are continuous, and at the junctions of the right and left-hand portions there is no departure from the true involute shape.

In order to obtain very high gear ratios, straight-tooth pinions with three teeth have been used in the past. With helical teeth, however, it becomes practicable to design the pinion with one tooth in such a way that the transmission is positive and perfectly uniform. In contrast with a high-ratio worm gear drive the one-tooth helical pinion and wheel should show a greatly increased efficiency.

The example illustrated has a ratio of 63 to 1, since the wheel has 63 teeth. Other data connected with the design are as follows :—

	Pinion.	Wheel.
Pitch circle diameter	0.508in.	32.004in.
Outside diameter	1.756in.	32.210in.
Diameter of shaft	1¼in.	
Pitch	1.968 D.P. or 1.595in. circular pitch.	
Face width	6in.	
Centre distance	16.26in.	
Pressure angle	22 deg. 10 min.	
Ratio of pitch diameters	63 : 1	
Ratio of outside diameters	18.28 : 1	

It will be noticed from the line engraving that although the pitch circle of the pinion is only a shade over half an inch in diameter, the abnormally large outside diameter gives the pinion a section which—or so it is claimed—is



ONE-TOOTH DOUBLE HELICAL PINION

such as to enable the gearing to transmit the designed power without undue deflection. The action of the tooth contact is almost entirely of the "recess" kind, that is to say, it takes place when the pinion is going out of engagement with the wheel. This condition, it is claimed, promotes efficiency and assists good lubrication, because it results in the oil being drawn into the line of contact. It has been suggested by some authorities who have examined the gearing that there is excessive sliding action between the teeth. The makers contend, however, that the results of the tests on the gearing prove that whatever amount of sliding action there may be is not harmful, and that, providing such action takes place in recess, it is apparently an advantage.

Boiler Inspection on the G.N.R.

THE Buxton explosion has had the result of causing chief mechanical engineers to look more closely into the question of the shed inspection of boilers, and to regularise more closely the methods employed. Mr. Gresley, of the Great Northern, has instituted since January 1st of this year a card index scheme which, we believe, will be of interest to our readers, and we therefore illustrate the set of cards herewith to a reduced scale. It must be clearly understood that the inspection has always been carried out, but there has never been that precision about the routine that is established by this system. Mr. Gresley's memorandum to the "sheds" is given below.

INSTRUCTIONS FOR THE DISTRICT EXAMINATION OF LOCOMOTIVE BOILERS, COMMENCING JANUARY 1ST, 1922.

Boiler.—The fire-boxes of all engines at out stations must be examined twice in every month by the authorised boiler examiner or his deputy; the first examination to take place in the first half of the month and the second examination in the second half. The boiler stays must be tested with a hammer at each examination. One man in each district to be appointed for this purpose. After each examination of a boiler the examiner to fill up Card No. 4391, stating opposite each heading the defects discovered, and if no defects he will put "O.K." He will then sign this card and hand it into the office. The work booked on this card to be copied on to ordinary work cards and given out by the boilersmiths' foreman in the usual way. When all the work booked to one boiler is completed the card to be signed by the foreman boilersmith and the date of repairs completed on the summary card.

Lead Plugs.—Lead plugs to be changed every month whatever their condition. The numbers of all the engines on which the lead plugs are changed to be entered up on Card No. 4393 by the man who does the work. This card to be handed in at the office on completion of his days' work and from it the engine summary cards to be entered up.

Water Gauges.—Water gauges are to be examined every month. The balls and check valves to be removed and cleaned, the gauge cocks to be examined so that they work freely and are steam and water-tight and the passages into the boiler and to the gauge glasses are clear. This card, No. 4395, to be made out, signed by the examiner and handed into the office for the particulars to be entered on the summary card.

Safety Valves.—Safety valves are to be tested every month with a test gauge by the man authorised for this work. No error above the working pressure is to be allowed, but an error not exceeding 5 lb. below the working pressure may be allowed. The examiner to fill up each month the first portion of Card No. 4394. This card to be signed by the examiner and handed into the office for particulars to be entered on the summary card. Should any work be done to the safety valves, such as the grinding in of the valves, dismantling of the spring or the adjustment of the pressure, this work must be done by the man specially authorised in each district, who will then complete the bottom portion of Card No. 4394.

Examination of Foreign Engines.—When foreign engines are examined the examiner's card must be sent to the home depôt.

Stationary Boilers, Locomotive and Lancashire Types, and Motor Lorries.—The foregoing instructions also apply to these boilers save that they are to be examined by the district boiler examiner once each month, and the other examinations are to be made every two months.

Vertical and Cornish Boilers.—These are to be examined every three months—three times annually by the district boiler examiner and once annually by the Doncaster boiler inspector. Safety valves and water-gauges to be examined every three months.

Further Supplies of Cards.—All further supplies of cards to be ordered in the usual manner.

CALENDARS, DIARIES, &c.

FLOWERDEW AND CO., 227-228, Strand, W.C. 2.—Smal calendar with monthly tear-off sheets.

HOLLINGS AND GUEST, Limited, Thimble Mill-lane, Birmingham.—Wall calendar with monthly tear-off sheets.

W. JOHNSON, GILL, SEALE AND CO., Limited, 322, High Holborn, W.C. 1.—Monthly tear-off sheet wall calendar.

BARFORD AND PERKINS, Limited, Peterborough.—We have received several calendar note-books from this company.

D.P. BATTERY COMPANY, Limited, Bakewell, Derbyshire.—Wall calendar, with monthly tear-off sheets. A view of Peveril Castle is reproduced in colours.

G. AND T. EARLE, Limited, Wilmington, Hull.—Large tear-off sheet wall calendar. The dates are given in bold figures! Each month up to 1924 is given.

CRANE-BENNETT, Limited, 45-51, Leman-street, E. 1.—Wall calendar on which a map of the world is reproduced. A daily tear-off sheet, the figures being red.

STEWARTS AND LLOYDS, Limited, Glasgow, Birmingham, London.—An exceedingly well-produced desk calendar. Monthly cards are mounted in a case, finished off in gold.

MILNER HURD'S PATENTS COMPANY, Limited, 4, Paradise-square, Manchester.—Wall calendar with daily tear-off sheets A view of one of the firm's productions is given in colours.

THE LEA RECORDER COMPANY, Limited, 28, Deansgate, Manchester.—A desk calendar for 1922. A week to a page is given and plenty of space is left for appointments and notes.

H. W. WARD AND CO., Limited, Birmingham.—An attractive coloured wall calendar with monthly tear-off sheets. Pictures of machines manufactured by the company appear on each sheet.

ASHWELL AND NESBIT, Limited, Barkby-lane, Leicester.—Wall calendar with daily tear-off sheets. On each sheet a quotation for the day is included. A view of Kodak Building is reproduced, in which Messrs. Ashwell and Nesbit installed the heating and ventilating plant.

Eng. No._____
Registered No. of Boiler _____ Working Pressure _____ Stationed at _____

SUMMARY OF DISTRICT BOILER EXAMINATIONS.

Year _____	Jan.	Feb.	March.	April.	May.	June.	July.	August.	Sept.	Oct.	Nov.	Dec.
Boiler—Date examined												
Boiler—Date Repair completed												
Boiler—Date examined												
Boiler—Date Repairs completed												
Lead Plug changed												
Water Gauges examined												
Safety Valves examined												

ENGINE SUMMARY CARD

G.N.R. LOCO. DEPT.

Registered No. of Boiler _____
Engine No. _____ *Working Pressure* _____ lbs. per sq. in. *Stationed at* _____

EXAMINATION OF THE BOILER BY DISTRICT EXAMINER.

Date _____	CONDITION	Date repairs completed.
Tubes		
Tube Plates ...		
Firebox Plates ...		
Firebox Side Stays		
Firebox Roof Stays		
Firehole		
Foundation Ring...		
Ashpan, Damper and Pinjours		
Brick Arch ...		

Signature of Examiner _____ *Work certified by Foreman Boilersmith* _____

SWAIN SC.

CARD NO. 4391

G.N.R. Loco. Dept.

Eng. No. _____ *Stationed at* _____
Working Pressure _____ *Date of Examination* _____

SAFETY VALVES.

Valves blow off at _____ lbs. per sq. in
Engine Pressure Gauge shews _____ lbs. per sq. in.
Signature of Examiner _____

2nd Test after adjustments. *Date* _____
Valves blow off at _____ lbs. per sq. in.
Engine Pressure Gauge shews _____ lbs. per sq. in.
Signature of Examiner _____

CARD NO. 4394

G.N.R. Loco. Dept.

Eng. No. _____ *Stationed at* _____
Date of Examination _____

WATER GAUGES.

CONDITION.	Date Repairs completed.
Ball & Check Valves ...	
Gauge Cocks	
Water Ways	

Signature of Examiner _____
Work certified by Foreman _____

CARD NO. 4395

G.N.R. Loco. Dept.

_____ *Depôt* *Date* _____

LEAD PLUGS CHANGED.

Eng. Nos.	Eng. Nos.	Eng. Nos.

Signature _____

SWAIN SC

CARD NO. 4393

The Interconnection of Alternating-Current Power Stations.*

INTRODUCTION.

SINCE November, 1916, when Mr. J. S. Peck read a paper† on this subject, several interlinking schemes have been put into commission or projected, and further experience in the operation of interconnected power stations under everyday working conditions has become available.

The purpose of this paper is mainly to show the importance of power factor phenomena in interconnectors, both on technical and on economic grounds. While the conclusions arrived at on the latter grounds apply with equal force to transmission lines which are not interconnectors, it is intended only to deal with the general problem of transmission lines connecting power stations.

In making a preliminary lay-out of an interconnector scheme the designer will be confronted at the outset with the problem: What variation in power factor will result from interconnection with a given voltage "boost" applied to the interconnector? And conversely: What voltage "boost" will be required to transmit power at a given power factor of transmission? As far as the authors are aware, equations for the solution of these problems are not at present available in a form so simple as to permit of rapid calculation. They have therefore added an appendix giving formulæ for estimating these values.

GENERAL OPERATING CONDITIONS.

It is necessary to emphasise one of the first principles—although it may appear to be a statement of the obvious—since there seems to have been some confusion of thought in the past concerning the transfer of power from one station to another.

The division of load in any desired proportion between two alternating-current power stations depends wholly on the adjustment of the steam supply to the prime movers. The more adjustment of the field strength of generators or the raising by other means of the voltage at the "sending" end of the interconnector only causes wattless kilovolt-ampères to flow around the circuit formed by the generators at the two power stations and interconnecting cable, the true power or kilowatts remaining unaltered, except for the load added by the copper loss in the interconnector. Adjustment of voltage, in addition to steam control, is necessary in certain conditions, which will be described.

There are three main conditions of voltage relationship under which power can be transmitted between two power stations, viz.:—

(1) *Station Voltages Constant and Equal.*—The mean power factor of transmission will remain at a constant leading value, the power factors at the station ends of the interconnector varying—but only within small limits—in opposite directions as the load varies or reverses in direction.

(2) *Station Voltages Constant and Unequal.*—The power factor of transmission will vary with the load in the direction of lag to lead as the load increases, and *vice versâ* as the load decreases. This method is suitable only for transmission of power in one direction.

(3) *Station Voltages Varied by Booster or other Means as the Load Varies.*—The power factor may be kept constant at any desired value within the range of the voltage variation available.

Under condition (1) power up to the capacity of the line may be transmitted in either direction without varying the voltage or mean power factor at all. Unfortunately, however, the majority of power stations are probably unable to receive and absorb into their systems a bulk supply at a leading—or even unity—power factor without very serious disturbance to their operating conditions. This method has therefore only a limited field of application unless special measures are taken to supply the large wattless component which might be required.

Under condition (2) the voltages are usually fixed to give the most desirable power factor of transmission at full load. This method is actually used with success in a number of cases where load is transmitted in one direction only. Its advantage over method (1) is that it makes it possible to transmit a fixed load at any desired constant power factor, but it also has some disadvantages. It is only suitable for transmitting power in one direction, as a reversal of power would flow at a low leading power factor. Further, as the load varies the power factor of transmission also varies within wide limits, and lastly, with a large voltage difference in the circuit it would hardly be practicable to operate without a regulator of some kind for the purpose of reducing the voltage difference when synchronism is approached or departed from, as without this provision the sudden making or breaking of the large wattless current which would flow at no load would have serious effects on the bus-bar pressure at one or both stations. These considerations appear to rule out a fixed voltage difference, where that difference has to be large, although this method gives fairly good results under favourable conditions, and where the transmission of power is to be in one direction only.

Condition (3) will, in the opinion of the authors, be necessary in the majority of cases. The variation of voltage may be obtained either

(*a*) By varying the bus-bar voltages at one or both stations, or

(*b*) By introducing "boost" in the interconnecting line.

In the case of power undertakings distributing alternating current, variation of bus-bar pressure for this purpose is inadmissible, since it means a corresponding variation in voltage at consumers' terminals.

The introduction of boost into the interconnector is therefore the only generally applicable method of varying the voltage relationship between the two stations. The variable boost in the line can be introduced by—

Induction regulators,

Static boosting transformers with step-by-step regulators, or

Variable regulating tappings on the main transformers.

TYPES OF REGULATOR.

Both the step-by-step and induction types of regulator have been used for many years for feeder regulation, and more recently for power station interconnector regulation. Both types have certain advantages and disadvantages, some of which have become more apparent under the latter conditions.

For large powers and high voltages the step-by-step regulator is at a disadvantage owing to the difficulty in building remote control switchgear which will connect the tappings of the main or auxiliary transformers in the proper sequence without breaking the main circuit. The latter requirement involves the provision of pilot contacts connected to preventive resistances or reactances in order to avoid short-circuiting sections of the transformer winding when passing from one tapping to another. The preventive resistances should be capable of carrying approximately full-load current at a voltage equal to the difference in pressure of adjacent tappings, and in frequent operation the duty may be very heavy. The difficulties encountered in the past with this type of apparatus are not insurmountable, and apparatus which it is believed will give satisfactory operation is now in process of development.

Contactor type and face-plate type step-by-step regulators are limited to pressures of about 3000 volts, and their use generally entails the provision of step-down transformers to bring the voltage on the switchgear within this limit, with an additional transformer to apply the boost at the required voltage. These transformers would each require to have a capacity in the same proportion to the full-load rating of the interconnector as the voltage boost is to the line voltage—allowing for transformer ratio—and the otherwise simple and inexpensive arrangement of contactors or face-plates becomes formidable under these conditions. Frequent inspection and overhaul is necessary, and this, in many cases, could be given only at considerable inconvenience.

Contactor type regulators have been constructed which vary the voltage on the line by shifting the neutral point of a star-connected three-phase transformer progressively up or down the winding, four or five taps being provided for this purpose. In order to limit the voltage between the contactor and earth to safe limits, the neutral point must be earthed in the regulator, and the system can, of course, only be arranged in connection with a star-connected winding. In spite of these limitations, however, this type of regulator undoubtedly has its field of application.

An induction regulator is in effect a transformer having one winding movable with respect to the other. It can be wound for pressures up to 11,000 volts and at this voltage is equivalent to the two auxiliary transformers and switchgear constituting the step-by-step regulator. There are no contacts to be kept in adjustment, while in fineness of voltage variation it is equal to a step-by-step regulator with an infinitely large number of contacts.

Interlinking schemes are often required to be reversible—that is, it must be possible to transmit power in either direction at short notice. This requirement simplifies the lay-out and design of the main and auxiliary apparatus to the extent that the plant at one end of the line can be a duplicate of, and interchangeable with, that at the other end; but, on the other hand, the cost of the installation may be increased by it. In the case of a scheme where it is required to deliver 10,000 k.V.A. to either station from the other, and regulator capacity of 10 per cent. of the total power is required to compensate for the line and transformer drop, the main transformers, line, and regulators at both ends of the line would have to be capable of dealing with something over 11,000 k.V.A., although the apparatus at the receiver station would actually carry only 10,000 k.V.A.

EFFECT OF POWER FACTOR VARIATION.

The power factor at which the transmission of power over the interconnector is to be effected is an important consideration, since obviously the capacities of the line, main transformers, and auxiliary apparatus depend on it. Further—and especially when the power factor of the normal connected loads on the interlinked power stations is different—in certain cases it might easily happen that the station receiving power would find itself loaded with wattless kilovolt-ampères to such an extent as to neutralise the advantage anticipated from the interconnection. When the two stations concerned are under the control of one authority the division of the wattless component will probably be decided on the basis of joint maximum economy; but when one authority is purchasing power in bulk from another the power factor at which the sale of power is to be effected should be agreed upon after full investigation.

The table shows the effect on the station power factor for a hypothetical installation consisting of two power stations A and B, an interconnecting cable, and step-up and step-down transformers. Station A has a normal load of 20,000 k.V.A. at 0.9 power factor (lagging); and station B has 25,000 k.V.A. at 0.7 power factor (lagging). Station B is to purchase power up to 10,000 kilowatts from A.

The station power factors and transmission efficiencies have been calculated for four different values of power factor of transmission at the receiver end of the line, viz.:—

(1) At 0.7 lagging the normal power factor of the receiver station (col. 1).

(2) At 0.92 lagging, equivalent to 0.9 lagging at the sending station (the normal power factor of the load on that station) (col. 2).

(3) At unity power factor (cols. 3 and 3*a*).

(4) At 0.83 leading, this being the power factor at which transmission could be effected, for this particular case, with no voltage difference in the line (col. 4).

Columns 1, 2, 3, and 4 are calculated on the basis of one regulator at the sending end only. Column 3*a* is inserted for comparison with column 3, to show the slight variation caused by placing a regulator of half the total capacity at each end of the line.

Transmission at the power factor of the normal load of the receiving station naturally has no effect on the plant power factor at that station; the sender station power factor, however, suffers by the addition of the load represented by the bulk supply at a power factor lower than its normal power factor. In most cases this would be considered an equitable arrangement, and station A would be no worse off than if it were supplying an ordinary large consumer whose apparatus operated at a power factor lower than the normal. Transmission at the normal power factor of the sending station's normal load would leave that power factor unaffected, but the position would probably not commend itself to the engineer at station B, as his station power factor would drop considerably. Transmission at the leading power factor corresponding to equal voltages has even less to recommend it; in the hypothetical case tabulated the kilovolt-ampère load on the generators at station B is actually larger than it would be if no supply were being taken from station A. The only advantage of this method is that all auxiliary boosting apparatus is eliminated.

Station B Receiving 10,000 *Kilowatts at Various Power Factors.*

	Power factor at receiving end of interconnector as determined by voltage difference.									
	0.7 (lagging).		0.92 (lagging).		Unity.		Unity.		0.83 (leading).	
	k.V.A.	P.F.*	k.V.A.	P.F.*	k.V.A.	P.F.*	k.V.A.	P.F.*	k.V.A.	P.F.*
Station A—										
Own load	20,000	0.9 lag	20,000	0.9 lag	20,000	0.9 lag	20,000	0.9 lag	20,000	0.9 lag
Transmitted to B	16,300	0.68 lag	11,780	0.9 lag	10,580	0.996 lag	10,600	0.996 lag	12,070	0.89 lead
Total load on A	35,670	0.81 lag	31,780	0.9 lag	30,090	0.95 lag	30,130	0.95 lag	29,270	0.98 lag
Station B—										
Own load	25,000	0.7 lag	25,000	0.7 lag	25,000	0.7 lag	25,000	0.7 lag	25,000	0.7 lag
Received from A	14,280	0.7 lag	10,800	0.92 lag	10,000	Unity	10,000	Unity	12,070	0.83 lead
Resultant load on B	10,720	0.7 lag	15,660	0.48 lag	19,360	0.39 lag	19,360	0.39 lag	25,740	0.29 lag
Transmission loss as per cent. of kilowatts delivered	10.6 per cent.		6.1 per cent.		5.2 per cent.		5.5 per cent.		7.6 per cent.	
Booster capacity	2320 k.V.A. (14.2 per cent.)		1065 k.V.A. (9 per cent.)		588 k.V.A. (5.6 per cent.)		610 k.V.A. (5.74 per cent.)		Nil	
Column No.	1		2		3		3a		4	

* P.F. = Power factor.

The effect of this method is that all auxiliary boosting apparatus is eliminated.

Transmission at unity power factor has some considerable advantages. The capacity of the line and transformers, as shown in the table, can be materially reduced, while the transmission losses are a minimum. The power factor at station B is, however, objectionably low, and if this system is to be adopted steps would have to be taken to deal with the excessive wattless component which station B would have to provide. Fortunately, the means are to hand in the synchronous condenser, but it must not be assumed that the provision of a machine of this type is always the best solution of the low power factor problem. The synchronous condenser merely supplies the wattless component which would otherwise be borne by the generators, at one or both stations, and the capital cost of a synchronous condenser equipment would not be justified except in those cases—which may be numerous—where it would be impossible to carry the wattless component on the generators.

In the authors' opinion, while no general case can be made out for the use of synchronous condensers in connection with the interlinking of power stations, particular cases will arise in which substantial economies can be effected by their use, and this possibility should always be kept in mind when installing or extending an interconnecting transmission line.

DISCUSSION.

In opening the discussion, Mr. P. V. Hunter remarked that the subject was a very difficult one, and the condensed manner in which the authors had dealt with it was a praiseworthy achievement. He was pleased to find that they had emphasised the fact that the energy is controlled by the steam side of the plant, as it was important that that should be properly recognised. The authors had referred to three types of regulators, but it was a pity they had not advocated one particular type. Personally, he preferred the induction regulator. It was no doubt an expensive piece of apparatus, but its advantages would always justify the cost. The title of the paper was a little unsatisfactory, for it was to be remembered that it was not so much the power stations that engineers desired to interconnect as the distribution systems. A feeder for connecting one station with another was very uneconomical unless it also acted as a network feeder, and it should never be used simply for interconnecting purposes alone.

Mr. F. H. Clough thought that the authors had not dealt properly with the wattless component of the load, which in many instances was more trouble to power-station engineers than the energy component. He also considered that Steinmetz's system of calculation was preferable to the modified Kapp method which the authors had adopted.

Mr. H. Brazil referred to the question of earthing the

* Abstract of paper read before the Institution of Electrical Engineers by Messrs. L. Romero and J. B. Palmer.

† *Journal* I.E.E., 1917, Vol. 55, p. 61.

neutral in interconnected systems. In Mr. Peck's paper read in 1916 he said several methods of earthing were referred to, viz.: (1) Earthing one station at a time, so that when the two stations are working in parallel there is only one earthed point, but the neutral of the other station is earthed when the stations are separated; (2) to earth one station and to run a cable from that station to the neutral point bus-bar of the other station; and (3) to place a resistance or reactance in circuit with the neutral point at each station. In the discussion that followed Mr. Peck's paper, the first two suggestions were unfavourably received, and the third method was considered to be the best. The general opinion seemed to be that it was better to insert a resistance in the neutral conductor than to use a reactance. The object of using a resistance in that way was to reduce the shock on the system when a fault occurred, and also to limit the high-frequency current between the neutral points of the two interconnected stations. The fact that there was a difference in potential between neutral points was due to the difference in wave form, and the value which that difference of potential might attain did not appear to be properly understood. In stations where new generators were installed and where those generators were practically identical, the wave form of each machine might be the same and the circulating current negligible; but the question under consideration was that of coupling up distant stations, and it was reasonable to suppose that in many cases the wave forms of the generators in the two stations would be widely different. The maximum difference in potential he had observed was 1200 volts, and the maximum current resulting therefrom when the neutral points were solidly connected to earth were 170 ampères. The generator was rated at 3000 kilowatts at 10,000 volts, and the current flowing in the neutral conductor was therefore equal to the full-load current. As the set would not run in parallel with other sets under those conditions, a grid resistance was inserted in the neutral conductor, and in order to ensure that when a fault occurred sufficient current would pass to trip the circuit-breaker, the resistance was designed for 16.7 ohms. When the machine was working in parallel with reciprocating sets, the current which passed through the resistance was 64 ampères, whilst the pressure across the resistance was about 1080 volts. Being interested to know what would be the effect of reducing the value of the resistance, some tests were made with a view to settling this point, and it was found that whilst the volts dropped when the resistance was reduced, the current increased at a greater rate, and the kilowatt loss naturally also increased. Owing to the conditions under which the test was made it was not possible to reduce the resistance to the desired value, but by plotting a curve it was discovered that with zero resistance the neutral loss would be 200 kilowatts. He found difficulty in reconciling those figures with those given in Mr. Peck's paper, for with 30 per cent. of the generator current the loss was 69 kilowatts, and if the assumption in respect of the form of the curve was correct, the loss would be 200 kilowatts with full load current. Those values were not by any means negligible. The object to be aimed at was to reduce the circulating currents to the lowest possible amount by increasing the value of the resistance, but at the same time the resistance should be designed so that it would allow sufficient current to pass to trip the circuit breakers when a fault occurred. In the case referred to it was necessary to keep the resistance of the iron grid down to 16.7 ohms, and the continuous circulating current was 64 ampères. The ideal resistance would be one which would reduce the circulating current to a very small value and yet allow the full current to pass when a fault occurred. A carbon powder resistance would probably meet those conditions to a large extent, because its ohmic value varied with the applied potential.

Mr. J. M. Donaldson said that he would not like to go as far as Mr. Hunter in his advocacy that every interconnector cable should also act as a distributor. By interconnecting stations it was possible to run them more nearly at full load, and that had a greater effect upon economical running than the actual load factor of the system, as one station could assist the other. Trouble at one station might, however, upset the whole system. The company with which he was connected operated two stations in parallel, and no serious difficulties had been experienced. There was little doubt, however, that from the point of view of cable faults it was better to run stations separately. The ratio of reactance to resistance was an important factor, and various authorities had been consulted with a view to ascertaining what that ratio should be. One authority had specified 1.5 and another $\sqrt{3}$, but the actual value had been found to be 1.875. Arrangements were being made for putting in a reactance for increasing the synchronising power. It was desirable, he thought, that reactances should be placed in the centre of the system. He could not altogether agree that the induction regulator was the best arrangement for use on interconnected systems. In the first place, those regulators were not made in this country, or, at any rate, he had not been able to find a firm that made them; and, secondly, they introduced an objectionable phase angle between the current and pressure.

Mr. G. W. Partridge gave some interesting facts concerning what was done in the direction of interconnecting stations thirty years ago, when the Deptford and Grosvenor Gallery stations were coupled together. By way of indicating how those stations behaved when running in parallel Mr. Partridge mentioned that Kelvin balances were used for measuring the current, and owing to the interchange of power between the stations the weights had to be tied on to the instruments. Referring to the authors' paper, Mr. Partridge said that the subject ought to be divided into two parts, one part dealing with interconnected stations that are close together, and the other with stations separated by great distances, for the short-circuit current would obviously be different in the two instances. In the former case it was desirable that in the event of trouble the system should be subdivided automatically by the introduction of reactances or by disconnecting stations by means of switches. He was inclined to agree that the induction type of regulator was the best arrangement to use for varying interconnected station voltages, but it was rather liable when connected in series with capacity, such as that of a cable, to produce pressure rises. The reactance of interconnected systems should never be less than the resistance.

Mr. Everest said that he noticed that the authors had used the term "synchronising power of the line." It was difficult to understand what that meant, and he would like to ask, he said, whether it would be possible to calculate the synchronising power without taking the internal reactance of the alternators into account.

Mr. L. Romero was then called upon to reply. Dealing with Mr. Hunter's remarks concerning the title of the paper, he said that he was inclined to agree that it was electricity supply systems that should be coupled together rather than their stations. There were, however, a great number of instances in which it would not be practicable to use an interconnector as a distributor. Moreover, the calculation of the voltage drop in the combined interconnector and distributor would be a complicated task, and he did not quite see at the moment how he would set about making such a calculation. Mr. Clough had made some remarks about the disadvantage of the receiving station taking the wattless component, but he regretted to say that he had failed to grasp his point. As for the formulæ and diagrams which Mr. Clough had criticised, he was of opinion that they were the simplest and best that could be used. Mr. Brazil was right in his assertion that the earthing question was one which still called for investigation. He believed that the Board of Trade regulations which specified that a system should only be earthed at one point was still in vogue, but there was little doubt, he thought, that it would have to be abolished. On one of the American electricity supply systems there were no fewer than 160 earth connections, and no trouble was experienced. Mr. Donaldson's remarks called for little comment, because they related mainly to a successful practical application of the interconnection system. Mr. Donaldson had, however, intimated that cable faults were likely to be worse on an interconnected system than on an ordinary system worked from a single power station. He would like Mr. Donaldson to consider, however, whether those faults were likely to be any different if the same amount of plant was in use in both cases. In other words, would the cables be liable to suffer more severely by putting all the plant in two stations instead of a single station? He quite agreed with Mr. Partridge in that interconnected power stations should be divided into two classes, namely, stations that are close together and stations that are a long way apart. It was not quite clear why the induction regulator should give a pressure rise any more than any other inductive piece of apparatus.

Mr. Palmer also made a few remarks concerning Mr. Everest's criticism on the expression "synchronising power of the line," and pointed out that he and his colleague Mr. Romero had tried to get a value which would compare different interconnecting lines. If the generator voltages at the two ends of the system were kept constant the line was the only thing that determined the synchronising power.

INSTITUTION OF ELECTRICAL ENGINEERS.

THE following is the list of speakers at the three sessions to be devoted to "Reminiscences and Experiences of Electrical Engineering," at the forthcoming meetings which are being held to commemorate the first meeting of the Society of Telegraph Engineers, which was held in February, 1872:—

Wednesday, February 22nd, 3.30 p.m.—Colonel R. E. Crompton, C.B., R.E., who will be followed by Mr. S. Evershed, Mr. E. Garcke, Mr. W. Judd, Dr. G. Kapp, Sir Alexander Kennedy, F.R.S., Sir Oliver Lodge, D.Sc., F.R.S., Lord Parmoor.

Thursday, February 23rd, 3.30 p.m.—The Hon. Sir C. A. Parsons, K.C.B., F.R.S., who will be followed by Mr. Frank Bailey, Sir T. O. Callender, Dr. S. Z. de Ferranti, Mr. J. H. Holmes, Mr. W. H. Patchell, Mr. J. Swinburne, F.R.S.

Thursday, February 23rd, 8 p.m.—Mr. J. E. Kingsbury, who will be followed by Mr. Ll. B. Atkinson, Mr. B. M. Drake, Sir William Noble, Mr. G. W. Partridge, Mr. A. A. Campbell Swinton, F.R.S., Mr. A. H. Walton, Mr. C. H. Wordingham, and Mr. A. Wright.

COMPRESSORS DRIVEN BY SYNCHRONOUS MOTORS.—With reference to an article which appeared in our issue of January 27th, entitled "Angle Compound Air Compressors at Bowden Close Colliery," we mentioned the maker's belief that these compressors were the first in the United Kingdom to be driven by a self-starting synchronous motor. The Ingersoll-Rand Company now writes to us to point out that a similar installation was made by it as long ago as 1916 at the North Navigation Collieries, South Wales, and that it has supplied compressors driven by synchronous motors since 1911.

THE GEORGE MONTEFIORE FOUNDATION PREMIUM.—A premium, known under the name of its founder, George Montefiore, is awarded every three years, as the result of an international competition, for the best thesis on the advancement of science and progress in the technical applications of electricity. The theses are judged by a jury composed of ten electricians, five of whom are Belgians and five chosen from foreign countries. The prize is derived from the accumulated interest on a capital sum of 150,000f., which is invested in Belgian 3 per cent. Rentes. The competition, which should have been held in 1920, has been postponed till 1923, when the value of the premium will be 21,000f. Further information may be obtained on application to Monsieur le Secrétaire-Archiviste de la Fondation George Montefiore, Rue Saint-Gilles, 31, Liége, Belgium.

THE JUNIOR INSTITUTION OF ENGINEERS.—The annual dinner and ladies' night of the Midland Section of the Junior Institution of Engineers was held at the Midland Hotel, Birmingham, on January 31st, Mr. R. B. Asquith Ellis, A.M.I. Mech. E., in the chair. Some seventy members and guests were present. Following the toast of "The King," Dr. C. C. Gerrard (honorary member) presented an electric gong to the Section on behalf of the members of the General Electric Company. Mr. Ellis accepted the gong in the name of the Midland Section, and immediately made use of it to call on Mr. E. C. R. Marks, M.I. Mech. E., to propose the toast of the "Institution," which was replied to by Mr. W. A. Tookey, M.I. Mech. E. (hon. treasurer), in the absence of the Chairman of the Institution, Mr. E. C. West. Mr. Tookey then gave a *résumé* of the work of the Institution, and remarked on its steady growth. Other toasts were the "Midland Section," proposed by Principal Schofield, chairman of Loughborough Section, and responded to by Dr. C. M. Walter, chairman of the Midland Section; "Kindred Associations," proposed by the President and seconded by Mr. R. A. Chattock, M.I.E.E.; "Our Guests," proposed by Mr. G. W. Costain, and replied to by Mr. Hyde; and the toast of "The Ladies," proposed by Mr. E. M. Boote, vice-chairman of the Section, and replied to by Mrs. R. B. A. Ellis. The gathering was a success in every way.

Provincial Letters.

THE MIDLANDS AND STAFFORDSHIRE.

(From our own Correspondent.)

The New Prices for Staffordshire Marked Bars.

THIS week new prices have been in operation in the Staffordshire marked bar trade following upon the decision of the Staffordshire Marked Bar Makers' Association at the end of last week to reduce prices 30s. per ton. Since November 24th last the standard has stood at £16, so that it now becomes £14 10s. During the war marked bars were sold at £33 10s. The deflation has been in progress since the beginning of last year, £19 having been taken off in eight instalments. The price is lower to-day than it has been for nearly six years. It is still £6 above pre-war level, but when comparison is made of the cost of labour, materials and transport then and now, it is an easy deduction that the £8 10s. was a more profitable price than the £14 10s. is. Happily, the best iron which the world produces is made in South Staffordshire. There are therefore still orders for marked bars, although the price may be deemed high. The ascendancy of steel does not affect the fibrous iron, which is one of the specialities of the district, and which figures so prominently in some of the most exacting engineering specifications. Without having any precise data to refer to, one might hazard the conjecture that there are more puddling furnaces in Staffordshire than in all the other iron-working districts of England put together. Staffordshire remains the foremost seat of the finished iron industry, with its hundreds of puddling furnaces and its thousands of skilled puddlers. It behoves the district jealously to guard its reputation for finished iron. The marked bar makers, like the steel makers and the West Coast hematite makers, emphasise the point this week that in making this new 30s. reduction they have discounted all the relief of which there is any prospect in respect of raw materials or railway rates, and they state that future reductions of selling price can only come from a broadening of the market. Hence, they argue, as I dispatch this letter, it is false reasoning for consumers of best iron, whether home or export, to further withhold orders on the hypothesis that prices will thereby be forced lower.

Unmarked Bar Iron Prices Easier.

The severe selling in the Staffordshire unmarked bar iron trade has been considered by the Association of Bar Makers, with the result, as I stated in my letter last week, that for the time being the £13 minimum for Crown bars has been suspended, and for the present free competition is to be permitted. In taking this decision, the associated makers, of course, had before them the recent drop of £1 per ton in Scotch bars, leaving Crown quality at £11 10s. for delivery at Glasgow stations, and also the similar reduction in Lancashire bringing prices to £12, together with the reduction at Middlesbrough of 10s. per ton on the 7th inst. With facts like these in front of them, it was, of course, useless for the majority of the Staffordshire meeting to seek to bolster up the long discredited figure of £13 for Crown bars in the Midlands. Neither was it possible to refuse permission to those members of the Association who wished to compete with non-associated firms who have long been accepting £12 and under for second-class bars to take an independent course. It therefore comes to this, that while there is no formal reduction in Staffordshire Crown bars, actual selling prices are mostly reduced to anything between £11 15s. and £12 per ton. This is a few shillings above the price lately accepted by non-associated firms, these last freely quoting bars at £11 10s., and in some instances even £11 5s. But it is quite usual for consumers who have been accustomed for years past to get their iron from a particular firm to pay a little more for material of which they have had experience. The decision to permit free competition has given general satisfaction to the associated bar makers, with the result that a considerable proportion of the business lately captured by unassociated firms will now, it is believed, be recovered. Orders at the local ironworks have been rather more numerous of late, warehousemen, whose stocks have been getting low, having now decided that the time has arrived to place orders on a cautious scale. There is still, however, a great deal of idleness among the local ironworks. Nut and bolt and fencing iron have seen a further fall of 5s. to 10s. per ton on the week, and can now be bought at a minimum of £11 per ton delivered in the Black Country at consumers' doors. Some offers of No. 3 Belgian iron bars at £9 10s. to £9 13s. delivered has led to the placing of some orders in Belgium. This material is generally used for nut and bolt making, but very few of the Black Country nut and bolt works are now operating more than half time, and there are rather large tonnages of bars in stock, some of it left over from the boom period, and therefore bought at high prices. The shipbuilding trade, usually the best customer for nuts and bolts, calls for only small tonnages just now. Galvanised sheets are a dull market, even at the low price of £16 f.o.b., and sellers are constantly pressed to make concessions even on that.

Steel Situation—Advance in Scotch Prices.

Steelmasters in this district express much gratification at finding that the result of the recent meeting of the Iron and Steel Makers' Federation in London concerning the prices of steel sheets and sections is that Scotch prices for the home trade have advanced £1 per ton, and export prices 5s. per ton. This brings Scotch sheets to £10 10s. for the home trade, and sections in proportion. The Midlands, like other parts of the kingdom, have for some time past considered it a serious grievance that Scotch makers should be underquoting them by 20s., and it is extremely gratifying that this state of things is now once again, officially, at any rate, at an end. It is said that pressure has been brought to bear on Midland steelmakers by buyers to reduce their prices, but the effort has been met with a refusal, the steel manufacturers declining to increase the losses which, they say, present prices involve. Dissatisfaction is expressed at the un-

profitable character of a good deal of current business. One manufacturer of plates, for example, states that he is losing £2 per ton. One or two wagon orders have been placed lately calling for steel for some leading district firms. Staffordshire rolled steelmakers are gratified that several large Indian and colonial contracts, calling for heavy tonnages of steel, are pending in the country. Another encouraging development is the increasing flow of loans to the Colonies and the Dominions. This is a form of financial fertilisation expected sooner or later to bring a healthy crop of home business in the heavy steel trade.

Bessemer Billet Business.

Bessemer billets rule at about £7 10s. In one case supplies have been offered at a lower rate, but the incursion is not such as to unsettle the Birmingham market. Numerous Belgian steel works have been sounding the Birmingham market lately with a view to obtaining business, but the prices quoted, with one or two exceptions, offer no advantage. Germany has also been diligently touting for business. Quite apart from the price question, the English manufacturer now generally, happily, gets the preference by virtue of his ability to give prompt delivery.

Dearer Coke and Pig Iron.

The Birmingham pig iron market is dearer by reason of the surprising advance which has just occurred in coke values. Furnace coke has indeed been advanced by several shillings, a jump in respect of some ovens from 17s. to 22s. Here and there, pig iron sellers are asking 5s. advance, but such a demand immediately stops sales. As regards demand, the position has changed very little, orders as a rule being scarce. But some encouraging foreign inquiries have been in the market lately, one received by a Midland firm running into some thousands of tons. There are still, however, large stocks at the furnaces.

Foreign Competition in the Wrought Iron and Steel Tube Trade.

Mr. J. Howard, chairman of Messrs. Stewarts and Lloyds, speaking at a recent meeting in this district, emphasised the necessity for greater production in order to combat the competition of foreign countries. He pointed out that during a recent visit to America he saw most of the large wrought iron and steel tube-making plants possessed by American firms, and he could tell them that if these were samples of American plants as a whole, the British manufacturers and workmen had got to be very efficient if they were going to hold their own on the revival of trade. If they were not they would find that the Americans, and possibly the Germans and Belgians, would make trade more difficult than it was. In his opinion, cheap production depended on increased output, and to get the maximum output of really good stuff from any works there was no room for slackers.

Flaws in Iron Castings.

In the course of delivering a paper on the "Production of Iron Castings," to the Wolverhampton Branch of the Birmingham Metallurgical Society, on Wednesday last, Mr. F. S. Wilkinson, of Dudley, had some interesting things to say with regard to flaws in castings. Many flaws, he said, could be traced to faulty preparation of the moulds. "Scabs" were due to faulty venting, or to too hard ramming, or to too much moisture in the sand. In the case of dry and loam moulds, the "scabs" could be traced to insufficient drying. "Blow-holes," which are due to bad casting, might be caused through the mould or the metal. A mould which had been rammed too hard or was too damp was very liable to "blow." Other difficulties might be traced to faulty design, and draughtsmen and patternmakers, in designing castings and making patterns, should avoid sharp corners and angle thicknesses where possible.

Briquetting Machinery for Australia.

Machinery engineers here are rather surprised and not at all pleased with a manifesto that the Agent-General for Victoria (Australia) has just made public in this country respecting his recent statement that it was impossible to obtain the briquetting machinery for the Morwell Brown Coal Mines from any country except Germany. It will be recalled that the Federation of British Industries protested that not only could the type of briquetting plant required be obtained in this country, but that a Birmingham firm actually quoted for this particular order. What is stated now is that it was never alleged by the Victorian Government that British manufacturers did not make satisfactory plant for briquetting black coal or refuse fuels with the use of binding materials, but the investigations of their expert demonstrated that the production of briquettes from brown coal without the use of binding material was impossible on a commercial scale by the use of any machinery obtainable in Great Britain. The contention, therefore, now is, not that briquetting machinery could not be supplied, but that the special type required could not be supplied. It is admitted that two British firms submitted projects, but they were unsuitable for the purpose. A Birmingham representative of the Federation of British Industries, however, states that this is not correct, and that the Birmingham firm previously mentioned can supply the special type of machinery required.

Wages in Black Country Chain Trade.

As a result of conferences between representatives of employers and employees in the Black Country chain trade, an agreement has been arrived at whereby a reduction of 12½ per cent. on the present rate of wages paid to the operatives has come into effect this week.

Electricity Extensions at Worcester.

Worcester proposes to spend £62,000 on electricity extensions, £24,000 of this amount being for generating plant lying at Southampton. The amount of plant to be removed will approximate 600 or 700 tons. The City Council has accepted a tender for the extension of the Hylton-road station at the price of £6750, and it has been further decided to carry out excavations, &c., at an estimated cost of £2000, by direct labour.

LANCASHIRE.

(From our own Correspondents.)

MANCHESTER, Thursday.

Iron, Steel, and Metals.

THE general condition of the markets in Lancashire does not show the slightest improvement at present, and the demand all round is about as poor as it can be. It is not now so much a question of prices—although it is true that the high prices of the previous twelve months have driven a large amount of work out of the district. Most consumers of iron, steel and metals admit that the present prices are in no case unreasonably high, and in many cases are absolutely low; but they do not buy because they have no orders on which to use the material. The district is, of course, unfavourably situated, so far as transport is concerned, for the increased railway rates are particularly irksome to Manchester, where scarcely any of the raw material used in engineering is actually produced.

Metals.

The further fall in the prices of copper has certainly produced a very bad effect on the minds of buyers here; for it was pretty confidently believed that when the market touched £70 per ton the rock bottom had been reached, and that it was impossible for any further serious fall to take place. As a matter of fact, buyers seem now to have less confidence in copper at £65 than they had at £70. The condition of the market is so far improved that refined ingot is no longer sold at the same price as standard; but there is very little demand for it for engineering purposes, and one doubts whether any conceivable process of cheapening would increase the demand. There has been a trifling reduction in the prices for tubes and sheets, but not so much as might relate simply to the fall in standard: and hence nothing has been done to reduce the considerable differences between refined and manufactured copper or brass. The new prices announced are £92 per ton for strong sheets, £102 for flat copper bottoms, £130 13s. 4d. per ton for solid-drawn and brazed locomotive copper tubes, £112 per ton for brass locomotive tubes, and £140 per ton for brass condenser tubes. Brazed brass tubes for the home trade are still quoted at the same price as brazed copper tubes. It is very difficult to say what may happen to copper prices during the next few months, but if the exchange between Great Britain and America goes back to par—and some people seem to think that it will—it is possible that yet lower prices for refined copper will be seen on this side. There was a slight recovery in tin after the recent fall, but this seems to have passed again, and in the absence of new demand there has been considerable weakness. The fact that there is a large stock of metal held back in the East has a very depressing effect even although people should place implicit confidence in the theory that this metal is not to be put on the market until it can be sold at a profit. The theory seems now too much like saying that the holders will wait for the Greek kalends before selling. The actual output of tin is quite sufficient for present needs without trenching upon stocks. Lead, after a slight reaction has again become a weak market and now looks very much like going lower. The market for spelter is quiet and rather depressed, and it seems to be expected that America will take advantage of the high exchange to sell in this market.

Pig Iron.

The market here for all classes of pig iron is very much as it has been for a month or so. There is very little demand, and prices are in a stagnant condition. So far as the sale of foundry pig iron is concerned it would not now be possible to stimulate it whatever concessions might be offered by sellers: and this they know perfectly well. The ironfoundries of the district have very few orders on their books, and simply buy small lots of foundry iron to keep themselves going from week to week. A fortnight ago there were rumours that the price of Cleveland foundry was to be cut again; and curiously enough there are now rumours to the contrary effect. It is thought that the fact that the make of Cleveland iron is now all being sold will induce the producers to try for more money; but while so many furnaces are still idle that would surely be a foolish policy. Everyone knows that in the end a lower level for pig iron has to be established before the trade can be got into a sound position; and an ephemeral rise would not benefit anyone in the long run. The prices in the Midlands are still very much lower than in the Cleveland district, and this is not a natural condition for the iron trade. Forge pig iron is neglected here, and seems still to be nearly 10s. below the price of foundry.

Finished Material.

The market for sectional steel and for plates is steady, but very quiet here. The new fixed prices for the home trade seem to be maintained for the present; but, of course, the home consumer resents them when he sees export business done on such much more reasonable terms. It has, of course, to be remembered that the manufacturer of steel does not get any extravagant profit out of the home prices. In fact he maintains that he is working at a loss. The Lancashire iron manufacturers have not reduced their prices below £12 per ton for Crown bar iron, but one hears of a so-called second quality at less.

Scrap.

The market for scrap is without change, except that the Lancashire consumers of heavy wrought scrap are now offering only £3 5s. delivered for it. There is very little demand for this or for foundry scrap, but the nominal prices of the latter have not been altered.

Optimism in the Cotton Industry.

The publication of the Board of Trade returns for January show that the exports of cotton goods to China were larger than in any month last year, and those to Bombay were well above the average, but the exports to Bengal were below the average. There were also increases of exports to Switzerland, Greece, Germany, United States, Colombia, Argentina, Egypt, British West Africa, Mesopotamia, Turkey, Australia and Canada, which would seem to indicate that the general fall in prices is commencing to bear fruit in the shape of an increased export trade. The exports of cotton yarns were, in fact, double those of January, 1921, in weight, and cotton piece goods higher by about 37 per cent. in yardage. The exports of textile machinery, chiefly to India, China, Japan and France, also show an increase compared with the corresponding month last year, all of which furnishes reason for the slightly more optimistic view which is commonly held with regard to Lancashire's staple industry. It is, however, chiefly in the minor markets where improvement is reported. The great Indian market is restricted by the import duty of 7½ per cent. on Lancashire goods, and Lancashire manufacturers are "moving heaven and earth" to secure the abolition of this handicap.

The Engineering Trades.

The general condition of the engineering industry in Lancashire, if no better than it was a month ago, *is* certainly no worse. In some sections there are, in fact, distinct signs of revival, and several important orders have recently been placed with engineering firms in this district. I am told that the demand for tool steel is larger than it has been for some time, but whether this is due to the steady depletion that has been taking place in anticipation of reduced prices or not, I am unable to say. A prominent employer of labour to whom I was speaking a few days ago on the subject of labour remarked upon the noticeable improvement in the individual output of the men in his employment since short time working had been in operation. It is not only in output that there is an improvement. The process of elimination in engineering workshops has been the means of improving the quality of the work turned out, for the best workmen only have been retained in many instances. The present is therefore an opportune time to place orders.

Manchester Ship Canal.

Although the results of last year's working of the Manchester Ship Canal show a reduction in the amount available for dividends for the shareholders compared with the previous year, the results when the depressing trading conditions are taken into account, may be considered fairly satisfactory. The holders of preference shares will get 3 per cent. and the "ordinary" shareholders 1½ per cent., while the Manchester Corporation will receive the full 3½ per cent. on the preference shares which rank for dividend before any shares held by the public. These shares, it may be recalled, represent interest arrears on £1,061,230 which was capitalised in 1910 for the benefit of the private shareholders, who would otherwise have had to wait until the whole amount had been repaid out of the company's profits. The preference and the ordinary dividends were 1½ and ¾ per cent. respectively for 1915, 2 and 1 per cent. for 1916, 2½ and 1½ per cent. for 1917, 3 and 1½ per cent. for 1918, 4½ and 2½ per cent. for 1919, and 5 per cent. on both classes for 1920.

BARROW-IN-FURNESS, Thursday.

Hematites.

The position of the hematite pig iron trade of North Lancashire and Cumberland is more promising than it has been for some time past. There is a fuller inquiry for iron and rather more business is being done. This business, however, is not yet of anything like big proportions, for buyers are content with placing contracts to cover their immediate wants; but as prices for the time being have become fixed it is expected that consumers will come forward more readily than of late. The production is somewhat heavier so far as Cumberland is concerned, and it is possible in view of the reopening of the Workington steel trade, that additional blast-furnace plant will be put into operation shortly. In the meantime orders are fairly well held, but at some of the works smelters have fair tonnages of iron and desire them to be cleared before there is a general resumption.

Iron Ore.

The demand for hematite iron ore remains easy and in the mining district there is a lack of industrial activity. Some of the mines are entirely closed. The Anticross mine of the Barrow Hematite Steel Company, near Dalton, was laid idle on Thursday last.

Steel.

At Barrow the steel trade is fairly well employed, the departments working this week including the Siemens branches, the rail and merchant mills, the steel foundries and the hoop mills. The general demand for steel is quiet. At Workington the fish-plate and tire mills are again working and the rail mills will resume operations on Monday next.

Shipbuilding and Engineering.

On Tuesday, Vickers, Limited, launched the oil carrier Scottish Musician for Tankers, Limited. She is of the same description as three craft already built for this firm. Work is very slack at Barrow, for there is nothing now on the stocks with the exception of a Cunard liner, work on which was stopped twelve months ago.

SHEFFIELD.

(From our own Correspondent.)

Slow Turning Tide.

DESPITE the more cheery tone one finds prevailing in the steel and engineering trades, it must be confessed that there are few tangible signs in support of it. In fact, the few items of news gathered during the past week all point in the opposite direction. There is, for instance, the decision of the Sheffield Simplex Motor Company to close down until there is a greater demand for its productions. The company—in which, as is well known, Earl Fitzwilliam, who is a keen and competent engineer himself, has a large interest—has been continuing its output until the firm's stores are overstocked both with cars and with the "Ner-a-car," the handy little runabout between a motor cycle and a car, which the company has been making during the last year or so. The company some few months ago was compelled to dispense with several hundred of its employees, and now the remaining 400 are added to the city's 49,000 unemployed. This decision, closely follows the closing down of the Alfreton Ironworks, a branch of the Stanton Company's works. The furnaces had been damped down since the coal strike, and the present decision means the complete closing down of the Alfreton works, where normally something like 700 men and boys are employed. There have been further dismissals at several of the principal Sheffield steel and engineering firms during the week, and most of these big works are carrying on very precariously, meeting the week-to-week orders which their customers restrict themselves to. One of the most reliable indications of the state of Sheffield's steel industries is the degree of activity of the Lincolnshire iron furnaces, and it is significant that of the twenty-three furnaces in the Scunthorpe and Frodingham district only six are in blast, and there are no immediate prospects of any more being started up. Moreover, some of the furnaces that had been re-started in Sheffield are proving very unremunerative, so small is the demand for steel. There is at present no sign of the re-starting of the huge melting plant at Templeborough, which has been standing idle for nearly eighteen months. With shipbuilding almost at a standstill, there is no demand for steel castings in any appreciable quantity. The only reassuring circumstance is the fact that inquiries are getting a trifle more numerous and definite. This is especially true of those from the British Dominions and Colonies, but purchasing powers appear to be very limited, and Sheffield is hoping that the recent and prospective flotation of new issues of capital on the market on behalf of some of the overseas Governments may permit the execution of certain big railway and electrification schemes that have been talked about for some time past. The conviction is growing on the part of Sheffield manufacturers that their only hope of renewed prosperity is in the direction of overseas orders.

Cost of Raw Materials.

Another satisfactory sign is a steady reduction in price of many of the raw materials required by the steel makers. The output of hematite pig iron is larger than it has been at any time since the coal strike, and the West Coast ironmasters have reduced their official quotation by 10s. per ton, bringing the price for mixed numbers down to £5 15s. per ton delivered Sheffield. The ironmasters, however, announce that this is as low as the price can come for a considerable time, as they have discounted reductions of wages and recent and future railway concessions and the price of fuel. At present the iron, they say, is being manufactured at a loss. The complete stagnation of the crucible steel market continues, despite lowering of prices. Tungsten powder, for instance, has gone below pre-war level, but this is quite an artificial circumstance, and is to be attributed to the surplus stocks. When these stocks are exhausted the supplies will inevitably be dearer. There is at the present, however, practically nothing being done in the tool steel departments. So far as coal is concerned, there are signs that the inland consumption of industrial fuel has been on a slightly larger scale. This increase is attributed to the slow but just discernible improvement in the heavy steel trade in connection with railway orders. The export trade is also a little brighter, and a number of railway contracts for steam coal has just been placed, in the case of South Yorkshire hards at about 21s. 6d. per ton up to the end of June; Derbyshire top hards are contracted for at 21s., and bottom hards at 6d. cheaper—the prices in all cases being at the pit. The railway companies had been putting off their contracts till the last moment in the hope of securing lower prices, but as they were quoted higher prices for current deliveries, the collieries may be said to have maintained the position as regards prices. Ultimately, it may be assumed, the prices paid by the railway companies will rule the market so far as inland supplies are concerned. Although there is still a certain amount of selling pressure in regard to small fuels, the position generally is decidedly steadier than it was a week ago. To some extent this is due to the fact that, tempted by the specially low prices at which spot lots had been offered, large users had taken advantage of the opportunity to build up their reserve stocks. The position of blast-furnace coke is a very strong one. At the moment the demand is greatly in excess of the supply, due largely to increased export and to inland consumption for purposes other than blast-furnace use, for which there is extremely little demand. Some of the South Yorkshire collieries are engaged in a welcome rivalry to establish new records in production; last week over 25,000 tons of coal were raised at the Brodsworth pit, beating the previous record of 24,582 made three weeks ago.

Disastrous Fire.

Following its water supply troubles the city experienced at the week-end one of the most devastating fires known in its history. The outbreak originated at the works of the Harris Furnace Company, Limited, and quickly involved the premises of a firm of manufacturing chemists; these were in close proximity to several other works, including a department of Spear and Jackson, Limited, the well-known steel and tool makers. The fire was attended by very grave risks to the brigades engaged; while the intensity of the heat from the blazing premises was such that it blistered the paint off the engines and set alight an escape and a tender. The weather conditions were so severe that the water froze at the nozzles of the hydrants and the hose. The damage is estimated at approximately £100,000. On the same day a fire at the edge tool works of Messrs. Spencer Bros. caused damage to the extent of £1000. These fires throw about 500 people out of work.

Dear Gas.

Sheffield City Council has decided to oppose the Sheffield Gas Company's Bill, in which it is sought to fix the basic price of gas at 9d. per therm. This, it was explained, is equivalent to about 3s. 7½d. per 1000ft., which is about four and a-half times the price of gas supplied for industrial purposes before the war, and about three times the cost of domestic supplies. The Parliamentary Committee of the Corporation contends that the price is too high for Sheffield, having regard to the natural advantages of its situation. Opposition is also offered on behalf of the trading and manufacturing interests in the city, many complaints being made not only of the high cost of the gas, but of the poor quality as compared with the pre-war supply. Electric melting furnaces are, as a consequence, coming into much greater favour.

Transport Matters.

Sheffield City Council is also interesting itself in the proposals of the railway companies to seek powers to run road transport. The Council fears competition with its own motor omnibus services, which have of late been considerably extended into the surrounding counties. The traders and manufacturers of Sheffield are, however, divided in opinion as to the wisdom of opposing the railway companies' application. Meantime a good deal of interest has been aroused in the proposal, to which I referred in this column a few weeks ago, to construct a new trunk road along the line of the Chesterfield Canal, which is now disused. A deputation, including the Mayor and ex-Mayors of Chesterfield and Mr. Charles Markham, head of the well-known engineering firm and owner of very considerable colliery interests in South Yorkshire, had an appointment to wait on Mr. Arthur Neal, at the Ministry of Transport on Tuesday, to solicit Government support for the conversion scheme.

Sheffield University and Industry.

Sheffield University is giving further evidence of its desire to foster local industries. The exhibition of foreign cutlery, to which I made reference last week, concluded with a most instructive and suggestive discussion, in which it was urged that from an engineering standpoint the German knives shown were excellent, and that in this country we were behind Germany in die-cutting, plating and oxidising. The Germans had less knowledge, said one speaker, but they beat us by applying all they had. It was also admitted that the American samples of pocket knives were highly creditable to the makers. It was, however, felt that the exhibition revealed the possibilities of enormous trade for Sheffield in the supply of medium and cheaper classes of knives, the market for which Sheffield has hitherto left pretty much to the Germans. The samples shown represented machine production, and it will be necessary for Sheffield to resort to the same methods if this competition is to be met. At present, however, there is still a strong prejudice against the application of automatic and semi-automatic tools to the cutlery industry, although it is pre-eminently suited to it. Another form of University activity is the commencement of a series of popular lectures in which Dr. Desch, the distinguished head of the metallurgical department, is explaining the origin and development of the Sheffield steel industry. Sheffield's establishment as a steel-making centre, he showed, was largely due to its favourable geographical situation. Solingen, which had a longer history in the cutlery world than Sheffield, had similar geographical conditions which determined the rise and development of the industry. The Applied Science Department of the University has made another new and interesting departure in instituting a series of lectures on foundry practice; these lectures are specially designed for practical workers with the intention of creating a real scientific interest in this old-established craft, on which Sheffield's industry is so vitally dependent. The lecturers are such acknowledged authorities as Dr. Percy Longmuir, Dr. W. H. Hatfield, and Dr. Desch. Dr. Longmuir gave the opening lecture, and dealt with the origin of the casting of metals in moulds. Still another interesting event in connection with the University during the past week is the appointment to the Chair of Mining of Mr. Douglas Hay, B.Sc., A.M. Inst. C.E. He is the son of Mr. W. Hay, the general manager of the Thorncliffe Collieries belonging to Newton, Chambers and Co., Limited. Mr. Douglas Hay has had colliery experience at Stanton and Tinsley Park, and before the war was a Junior Inspector of Mines for the northern district of Durham; more recently he has been Inspector of Mines in Staffordshire.

The Burst Reservoir.

Sheffield City Council, at its meeting last week, devoted a great deal of time to the discussion of the causes which led to the bursting of the balancing tank at the Bradfield reservoirs. This tank had a capacity of 5,000,000 gallons, and, as recently explained in this column, a fracture resulted in a flood which created a great deal of alarm locally, but luckily was unattended by loss of life or serious damage to property. It was stated that the concrete wall which gave way stood on a "fibrous" soil only 18in. below the surface, instead of being taken down to the solid rock 10ft. below. It was not disclosed by whose orders this was done. This reservoir was constructed as part of the scheme for the purification of water ultimately returned to the river Don as compensation water. By this means a considerable expenditure on additional waterworks had been avoided. The scheme was estimated to cost £324,743, but an inquiry has just been held with respect to the Council's application to borrow an additional £54,000, this excess being caused by the increased cost of materials since the work commenced. The inspector asked for further information respecting the bursting of the reservoir, which, it had been stated, would involve a further outlay of £7000, but at the request of the Town Clerk, who explained that this matter was to be the subject of further investigation, the inspector did not press for these details.

NORTH OF ENGLAND.

(From our own Correspondent.)

The Trade Position.

THE general position of trade on the North-East Coast has not undergone any outstanding development this week, but signs are not lacking that business in several sections is coming forward in more satisfactory volume than for a considerable time past. Certainly a more cheerful tone prevails in most of the markets, and the outlook is regarded as much brighter.

Cleveland Iron Trade.

The position of the Cleveland pig iron trade continues to improve steadily, and the future is looked upon much more hopefully. There is now very little prompt iron available on the market, and there is some talk of the possibility of more furnaces being put into operation. The ironmasters are very eager to get their men back to work and their idle plant into operation again, but to light up a blast-furnace is a costly business, and they are not likely to take the risk until they are fairly well satisfied that there is a market for the additional output. Still, the prospects are distinctly brighter. Business has opened out this month on a fairly good scale, so much so that the whole of the output in the Cleveland district for February has been sold, and if business continues to expand more furnaces will speedily be put into blast. In the meantime, the relative scarcity of prompt iron tends to stiffen the price. No advances have been imposed, but all Cleveland qualities are firmly held at the fixed minima, and only in mottled and white iron is there any pressure to sell. There was rather a lot of this low-grade iron made a few weeks back, owing to the irregularities ensuing upon the restarting of the furnaces, and makers are anxious to realise. No fixed prices are imposed, and the effect of competition for orders has been to depress the price to about 75s. per ton. No. 1 Cleveland and siliceous iron are quoted at 95s., No. 3 at 90s., No. 4 foundry 87s. 6d., and No. 4 forge 82s. 6d.

Hematite Pig Iron.

Business in hematite pig iron continues to improve. Makers are pretty well sold over the next few weeks, and the fact that ore and fuel prices are advancing has tended to firm up the price for hematite mixed numbers. Whereas a week ago they were offered at 92s. 6d., the quotation is now 94s. to 95s., but the half-crown premium for No. 1 quality has been reduced to 1s., so that the latter iron can now be bought at 95s. to 96s. There is an increasing demand for hematite, both from home and foreign consumers, and the make may speedily have to be increased.

Iron-making Materials.

Ore and fuel prices are steadily moving upward. There have been no recent fixtures from Bilbao, most of the foreign ore used being from Mediterranean ports, owing to the relative cheapness of the latter. But even on a 7s. 6d. freight, there are no sellers of best Rubio ore at less than 26s. per ton, and it is by no means certain that freight from Bilbao could be fixed as low as 7s. 6d. The amount of business in foreign ore, however, is very small, buyers simply coming on to the market for odd cargoes as the need arises, and then usually they require urgent delivery. A similar hand-to-mouth policy is pursued as regards coke supplies, and as the coke prices are going up consumers with no stocks to fall back on have to follow the market. Good medium furnace qualities are now fully 28s. 8d. per ton delivered at the works.

Manufactured Iron and Steel.

The stagnation in the manufactured iron and steel trade continues. The works on the North-East Coast are being very badly hit, and not the slightest improvement can yet be recorded. The shipbuilding slump is largely, but not entirely responsible, for orders for rails and constructional material only come in for very small quantities, and there is not a works which is fully employed. No alterations in prices are reported this week.

The Coal Trade.

The Northern coal trade has assumed a very strong position, and the outlook is very encouraging. The situation at the collieries in both counties is highly satisfactory, some of them being booked into April, while in very many instances they are sold and stemmed well past the middle of next month. It would appear that the continental demand, which was thought to be giving signs of shrinking at one time, is being slightly augmented almost every day, and the present indications point to a gradually expanding market, which may in the near future come within measurable approximation to the pre-war dimensions. The call for fuel for the German market is reported to be very heavy, and is the more astounding in view of the depreciated value of the mark, which must increase the ordinary price of coal by as much as forty to fifty times the quoted figure. Tenders have been forwarded for the supply of about 20,000 tons of Durham gas coals, with full options, to the Bergen Gasworks, Norway, for delivery from April to August next. There is now quite a number of foreign public companies' contracts under discussion, and the placing of them is followed with great interest, owing to the extensive competition to secure these orders, and because the price paid will give some lead to probable values for forward shipment. All classes of steams are scarce and in very

heavy demand, both for home and abroad. Values are not only maintained, but are improved upon as a matter of urgency. Best steams are firm at 25s. as a minimum for spot, but for the middle of March and onwards it is difficult to operate at current figures, which are not regarded as likely to be upheld for any length of time. All other grades of steams are correspondingly strong and proportionately high in value. The call for gas coals is very extensive, with all the prime and special brands on the rise, and even seconds are tending upwards. Coking coal is still a very strong feature, and being scarce top figures are easily obtainable for any date up to the end of next month. Bunker coals for the home waters are very firm, and prices are fully sustained, being supported by heavy shipments to Germany. Coke continues scarce and urgently sought after. Foundries of every make, together with all classes of gas coke, are only possible in limited parcels at top figures.

SCOTLAND.

(From our own Correspondent.)

Railway Rates Reduced.

As a result of a meeting held on January 6th last between representatives of the Scottish iron and steel manufacturers and the chairmen of the Caledonian, Glasgow and South-Western, and North British railways, it has been decided that modification by reduction should be made in respect of rates for the conveyance to blast-furnaces and steel works of coal, coke and patent fuel, lime in Class B of the general railway classification for iron and steel-making purposes, and iron and steel in Class B of the general railway classification. The modified rates, which will come into operation on February 15th, are as follow:—Coal, coke and patent fuel: The rates as at January 14th, 1920, plus 75 per cent., plus a flat rate addition of 4d. per ton, with a maximum increase of 3s. per ton. Lime in Class B of the general railway classification for iron and steel-making purposes, iron and steel in Class B of the general railway classification, viz., pig iron, scrap, billets, blooms, ingots, bars: The rates as at January 14th, 1920, plus 75 per cent., plus a flat rate addition of 4d. per ton. The proposal to reduce demurrage charges from 3s. to 1s. 6d. per day for the conveyance of iron and steel has not yet been agreed to.

Prospects of New Business.

Though general conditions are yet very slow, indications of better times are evidently taking more definite shape. Foreign markets are more active, and there is a distinct probability of further contracts. South America, South Africa and Australia are all inquiring for railway material and locomotives, and orders of considerable bulk are in contemplation. Competition is sure to be keen, but high hopes are entertained that local works will be able to secure a goodly proportion of the business. The Indian State Railways are also interested in material. Conditions at some of the shipbuilding yards, too, are said to be improving. At any rate, employment is somewhat better, especially in the case of joiners. It is rumoured also that German purchasers have recently—for the first time in ten years—been asking for Scotch pig iron to upwards of 200 tons. It appears to be generally recognised that unless something unforeseen occurs, price levels cannot decrease much further, and more activity in markets is anticipated in the near future.

Steel and Iron.

While the outlook seems a little brighter, orders are yet scarce, and works on the whole are moving slowly. Local makers, however, are now able to quote more favourable prices, and give better deliveries of more reliable material than their foreign competitors, and are now likely to get the preference when new business is in prospect. The hand-to-mouth system of buying is still very much to the fore, the idea of further price reductions evidently restraining buyers. Plates and sectional material are exceptionally quiet, though boilermakers have shown a little more activity of late. Galvanised sheets, too, are in better demand. The majority of the ironworks have very lean order books, and perhaps the latest cut in prices will prove of some benefit. The Scottish Black Sheet Makers' Association has now brought its prices into line with those of the Steel Makers' Association, and the new prices are as follows:—Sheets under $\frac{1}{4}$in. to $\frac{3}{16}$ in., £11 5s.; under $\frac{3}{16}$in. to $\frac{1}{8}$in., £11 15s.; under $\frac{1}{8}$in. to 16 g., £12 10s.; under 16 g. to 20 g., £13 5s.; under 20 g. to 24 g., £13 15s.; and under 24 g. to 27 g., £14 15s. per ton. The Scotch pig iron trade is exceptionally slow. Makers are doing everything possible to promote business, but requirements are few and nothing is being bought for stock. The engineering trades are very dull.

Coal.

Business in the Scotch coal trade was without fresh feature during the past week. The demand for round coal from the West of Scotland district continues dull, and the principal outlet is the request for washed fuels. Despite cheaper prices, overseas buyers are not placing large orders, but the total shipments from the district are better. The Fifeshire coalmasters are experiencing a fair general turnover, and the same may be said of the Lothians. In these districts also the demand for washed nuts is the dominating factor. Some comparatively cheap prices have been quoted for Fifeshire large coal, and this fact has brought out a fairly steady stream of orders. Shipping tonnage has not been too plentiful recently, and freights, more expecially to West Italy, have been firmly held. In the preceding week the freight rate from the Forth to West Italy dropped to 13s. 6d., but within the past day or two 14s. 6d. has been named. From Clyde ports to the same destination 13s. 9d. to 14s. is the rate. On occasion, however, much cheaper quotations have been heard of. Aggregate shipments from Scottish ports during the past week amounted to 241,607 tons, against 222,124 tons in the preceding week and 298,943 tons in the same week in 1913.

WALES AND ADJOINING COUNTIES.

(From our own Correspondent.)

Improved Coal Trade.

THE improvement which has been manifest in the coal export trade during the past week or so is encouraging. Whether it will be maintained remains to be seen, but the fact that progress towards activity in a real sense is slow is not in itself unhealthy, but rather the contrary, and in a way is preferable to meteoric movements, which are dangerous and by no means welcome. It cannot be denied that the attitude of the coalowners in steadfastly declining to continue the policy of cutting prices is partly responsible for the better state of things existing, as it has had the effect of making buyers abroad feel that the bottom of the market has been touched, and that unless they come along for supplies they might be caught on the rebound and have to pay prices higher than those now ruling. At the same time there are other considerations to be taken into account, viz., that outputs have recently been affected by so many men being laid aside by influenza and that February is a short month, with the result that exporters have to get away at an earlier date shipments to which they are committed. The point whether prices are likely to improve to any material extent depends whether the demand now prevailing not only is sustained but steadily expands and keeps abreast of increasing outputs. There is scope for marked expansion in production, as is shown by the number of unemployed, but while owners are prepared to do their utmost to find work for idle miners, at the same time it is not unlikely that they will want to be reasonably certain that there is an outlet for their coals at a remunerative figure before they seriously entertain developments on a substantial scale; while, furthermore, there is the question whether shipment facilities are adequate to deal with a much increased output. Lack of proper facilities means that coalowners have not a fair chance, as coal prices are kept down for the reason that when collieries have coals standing and are short of empty wagons they are forced to accept less than current values frequently in order to get clearance, and so enable their pits to continue working without interruption.

Spirit of Co-operation.

It is satisfactory to see the better spirit prevailing between capital and labour in different districts. Sir David Llewellyn reopened the Tower Colliery, Hirwain, on Monday last as the result of a petition which he received from 90 per cent. of the workmen, who promised him their fullest co-operation in the working and development of the collieries. Negotiations between the men's representatives and the management of Messrs. D. Davis and Sons have resulted in work being re-started at No. 8 pit at Tylerstown, where about 1000 men are engaged, and in the event of price lists being settled it is probable that full work will be resumed at Messrs. Locket's Merthyr collieries at Mardy this week, thus providing employment for 2500 men. Negotiations have also been opened for the re-starting of operations at the Bodringallt Colliery, one of the oldest in the Rhondda, belonging to Cory Bros. and Co., Limited. It is interesting to note that the principle of co-operation between the workmen and the owners, which has been in existence for rather more than a week at the Ferndale collieries belonging to Messrs. D. Davis and Sons, is proving a success. According to one of the leaders, the results are so gratifying that they are encouraged to persevere in the extension of the system. At each pit there has been elected a workmen's committee of six, which meets a committee of an equal number appointed by the management at the end of the working day to consider and remedy any complaints lodged by either side and discuss any differences that may have arisen. At the end of each week the men's representatives meet the general manager at headquarters and frankly discuss conditions of working and any other matter which will contribute to the improvement of output and the reduction of costs. In this way a healthier atmosphere is being created, and already it is reported that production has been beneficially affected, so that it is hoped that the danger of pits having to be closed on account of the cost of working will be averted.

Last Year's Trade.

Official returns are now available regarding the trade at several South Wales ports last year. The results shown are unfavourable when they are compared with those of 1920. Bad trade generally, and the coal strike in particular, are responsible for the unsatisfactory results. At the Bute Docks imports and exports together totalled 5,206,752 tons, as against 7,728,144 tons in 1920. Coal exports fell from 5,255,971 tons in 1920 to 3,880,554 tons last year. In the case of the Barry Docks, imports and exports came to 6,008,000 tons last year compared with 7,397,020 tons in 1920. Exports of coal declined from 6,897,949 tons in 1920 to 5,643,893 tons in 1921. At Newport the total trade of the port for last year was 3,423,469 tons as against 5,102,319 tons in 1920. Exports of coal fell from 4,348,932 tons to 2,986,669 tons, while at Port Talbot, imports and exports last year amounted to 1,069,333 tons as against 2,066,795 tons in 1920. Coal shipments fell from 1,607,581 tons to 792,611 tons.

Wage Agreements.

Agreement was come to on Saturday at Swansea at a meeting of the Conciliation Board of the South Wales tin-plate trade by which the workmen accepted the employers' offer of a special bonus of 7½ per cent. in lieu of bonuses amounting to 17½ per cent., which expired on the 4th inst. The men's representatives in the first place put forward an application for 25 per cent., and subsequently asked the employers to grant 10 per cent., but the employers expressed their regret that they could not see their way to accede to the latter owing to the serious condition of the trade. The coal tippers at Cardiff have confirmed the agreement which was arrived at by their representatives with the dock and railway companies recently, in London, respecting wages. The men have also considered an application from the railway companies to adopt a split shift in place of the present working arrangement, and have appointed representatives to attend a joint national conference of all the parties concerned in the shipment of coal to consider the matter.

Railway Amalgamation.

It is now announced that in all cases terms have been arrived at under which railways in the grouping scheme for this district are to be amalgamated. The line in which most interest centred was the Barry Railway, and it is understood that the terms come to with the Great Western Company are upon a basis which gives the Barry shareholders the equivalent of 11 per cent. upon the undivided ordinary. The exact terms are to be disclosed at the shareholders' meeting to-day (Friday). Barry stocks have shown a remarkable advance. The lowest prices last year were as follows:—Undivided ordinary, 102½; preferred ordinary, 45; and deferred ordinary, 55½. On Tuesday last the prices were as follows:—Undivided ordinary, 185½; preferred ordinary, 67; and deferred ordinary, 118.

Current Business.

The past week has seen a better demand for practically all classes of steam coals, and the tone is improved all round. Collieries are in a stronger position than they have been for a long time past, and are able to name higher figures, especially for this month's shipment, as order books are pretty well full and they have no coals to spare. The recent wintry weather has resulted in a brisker demand for the shipment of coals to France, while, of course, the home inquiry has also improved for the same reason. Sized coals are almost unobtainable for this month. Anthracite qualities are quiet, although nuts and cobbles maintain a relatively good tone. There is no change as regards coke and patent fuel, while pit-wood is about 30s. to 31s.

PERSONAL AND BUSINESS ANNOUNCEMENTS.

HYATT, Limited, asks us to state that to-morrow, the 18th inst., it will move from Thurloe-place, London, S.W. 7, to 56, Victoria-street, London, S.W. 1.

THE CONSIDERE CONSTRUCTION COMPANY informs us that it has moved from No. 5, Victoria-street, to No. 72, Victoria, street, S.W. 1. The telephone number will remain unaltered as Victoria 3033.

MR. GEORGE S. WILFORD, who for the past seventeen years has represented Cammell Laird and Co., Ltd., in the Midlands, has resigned his position with that company to join William McLean, Limited, Stirling Chambers, Sheffield. Mr. Wilford becomes a director of Messrs. William McLean.

SIMPLEX CONDUITS, Limited, of Garrison-lane, Birmingham, informs us that it has completed arrangements for a joint sales service with its associate company, Credenda Conduits Company, Limited, whereby all Simplex and Credenda productions will be available at the branches and depôts of both companies.

WE are informed that the business of Samuel Cook and Co., machine and spring makers, of Albert Works, Bury, has been acquired by Mr. Leslie H. Lomas, F.R.S., late of De Bergue and Co., Limited, Strangeways Ironworks, Manchester. The business will be carried on as heretofore under the old firm's name, and the services of Mr. Miley, the manager, have been retained.

THOMAS L. HALE, Limited, of Dudley Port, Tipton, Staffs, informs us that having made various alterations in its organisation, Mr. W. Clarkson, its late representative for London and district, has taken up a position on its directorate. It has appointed as Mr. Clarkson's successor Mr. N. Mitchell, 28, Flanders-road, Bedford Park, London, W. 4. Telephone Number 1065 Chiswick and telegraphic address, Umalsteclo Chisk, London.

CONTRACTS.—Clayton, Son and Co., Ltd., of Leeds, have recently been successful in obtaining orders for welded steel mains from the Birmingham Corporation Waterworks Department, and also from the Metropolitan Water Board.

"THE NEW FRENCH STEEL PROCESS."—In our issue of the 10th inst., p. 164, the statement is made that the "huge plant is being manufactured in Sheffield in connection with it at the Imperial Steel Works of Messrs. Basset of Paris." This should, of course, read, "At the Imperial Steel Works of Messrs. Edgar Allen and Co., Limited, for Messrs. Basset, of Paris," as in the letter from our Sheffield Correspondent.

SAMPLING AND ANALYSIS OF COAL COMMITTEE.—The Fuel Research Board of the Department of Scientific and Industrial Research has appointed a Committee to advise upon the sampling and anlysis of coal. The *personnel* of the Committee is as follows:—Professor Thomas Gray (chairman), Professor J. W. Cobb, Dr. J. T. Dunn, Dr. J. S. Flett, F.R.S., Mr. G. Nevill Huntly, Mr. S. Roy Illingworth, M.Sc., Mr. J. G. King, Dr. C. H. Lander, Dr. R. Lessing, Mr. C. A. Seyler, Mr. F. S. Sinnatt, and Professor R. V. Wheeler, the secretary being Miss N. Renouf. It is intended that the methods recommended by the Committee shall be adopted in connection with the physical and chemical survey of the national coal resources. Communications for the Committee should be addressed to the secretary at 16 and 18, Old Queen-street, Westminster, London, S.W. 1.

THORNYCROFT'S STAFF DINNER.—The annual dinner of the London staff of John I. Thornycroft and Co., Limited, held at the Holborn Restaurant on Friday, February 10th, proved a most enjoyable function. An assembly of over 120 filled the Crown Room, including visiting members from the staff of the Basingstoke and Southampton works and several of the company's provincial depôts, the chair being occupied by Mr. Alex. Glegg, the senior director of the company, supported by Sir John E. Thornycroft, K.B.E., the managing director. In proposing the toast of "The Chairman," Mr. R. C. Hewitson, assistant secretary, referred to Mr. Glegg's long association and adding a tribute to his guidance and an appreciation of the kindly interest he had always evinced in the welfare of the staff. In responding, Mr. Glegg expressed his thanks for the very cordial reception accorded him, which he interpreted as an expression of goodwill to the firm as much as to himself. Mr. C. H. Newman, in proposing the toast of "The Firm," sounded the most popular note of the evening when he referred to the very close association between the Thornycroft family and the firm, according a hearty welcome to Sir John E. Thornycroft, and recalling his presence amongst them on the occasion of their first dinner twenty-five years ago. In responding to the toast, Sir John was given a rousing reception, and in the course of his remarks referred to the approaching removal of the London staff to its new headquarters at Thornycroft House, Westminster, also to the new sports ground the firm had acquired for the use of the employees, which was now being prepared for the ensuing season. He then proceeded to present the prizes awarded to the winners of the sports competitions held during the past year. Other speeches followed, interspersed by a most enjoyable programme of musical and other items.

Current Prices for Metals and Fuels.

IRON ORE.

N.W. COAST—	
Native	37/-
(1) Spanish	28/-
(1) N. African	28/-
N.E. COAST—	
Native	—
Foreign (c.i.f.)	28/-

PIG IRON.

	Home. £ s. d.	Export. £ s. d.
(2) SCOTLAND—		
Hematite	5 5 0	—
No. 1 Foundry	5 7 6	—
No. 3 ,,	5 2 6	—
N.E. COAST—		
Hematite Mixed Nos.	4 14 0	4 14 0
No. 1	4 15 0	4 15 0
Cleveland—		
No. 1	4 15 0	4 15 0
Silicious Iron	4 15 0	4 15 0
No. 3 G.M.B.	4 10 0	4 10 0
No. 4 Foundry	4 7 6	4 7 6
No. 4 Forge	4 2 6	4 2 6
Mottled	3 15 0	3 15 0
White	3 15 0	3 15 0
MIDLANDS.		
Staffs.—		
All-mine (Cold Blast)	11 10 0	—
Part Mine Forge	*None offering.*	
North Staffs. Foundry (*Nom.*)	4 10 0 to 4 15 0	
(3) Northampton—		
Foundry Nos. 2 and 1	*Nominal.*	
,, No. 3	4 2 6 to 4 5 0	
,, Forge	3 15 0	—
(3) Derbyshire—		
No. 3 Foundry	4 5 0 to 4 10 0	
Forge	3 17 6	
(3) Lincolnshire—		
Basic	4 0 0 to 4 5 0	
Foundry	4 5 0 to 4 10 0	
Forge	4 2 6 to 4 5 0	
(4) N.W. COAST—		
N. Lancs. and Cumb.		
Hematite Mixed Nos.	5 15 0	—

MANUFACTURED IRON.

	Home. £ s. d.	Export £ s. d.
SCOTLAND—		
Crown Bars	11 10 0	—
Best ,,	12 0 0	—
N.E. COAST—		
Common Bars	12 0 0	—
Marked ,,	17 10 0	—
Tees	14 10 0	—
LANCS.—		
Crown Bars	12 0 0	—
Hoops	16 5 0	16 0 0
S. YORKS.—		
Crown Bars	12 0 0	—
Best ,,	14 0 0	—
Hoops	16 0 0	—
MIDLANDS—		
Marked Bars (Staffs.)	14 10 0	—
Crown Bars	12 0 0 to 13 0 0	
Nut and Bolt Bars	11 0 0 to 11 10 0	
Gas Tube Strip	12 10 0	—
Hoops (*Nom.*)	15 0 0	—

STEEL.

	(6) Home. £ s. d.	(7) Export. £ s. d.
(5) SCOTLAND—		
Boiler Plates	14 0 0	—
Ship Plates ⅜in. and up	10 10 0	—
Sections	10 0 0	—
Steel Sheets ⅛in. to ⅜in.	11 15 0	—
Sheets (Gal. Cor. 24 B.G.)	—	16 0 0

STEEL (*continued*)

	Home. £ s. d.	Export. £ s. d.
N.E. COAST—		
Ship Plates	10 10 0	—
Angles	10 0 0	—
Boiler Plates	16 0 0	—
Joists	10 10 0	—
Heavy Rails	9 10 0	—
Fish-plates	14 10 0	—
Channels	14 10 0	—
Hard Billets	9 5 0	—
Soft Billets	7 5 0	—
N.W. COAST—		
BARROW—		
Heavy Rails	9 10 0	—
Light ,,	11 0 0 to 13 0 0	
Billets	9 5 0	—
Ship Plates	10 10 0	—
Boiler ,,	14 10 0	—
MANCHESTER (*Prices irregular and uncertain, unchanged*)—		
Bars (Round)	10 0 0 to 12 0 0	
,, (others)	11 0 0 to 12 0 0	
Hoops (Best)	15 5 0	15 0 0
,, (Soft Steel)	12 5 0	12 0 0
Plates	£10 to 12	10 0 0
,, (Lancs. Boiler)	16 0 0	—
SHEFFIELD—		
Siemens Acid Billets	10 0 0 to 11 0 0	
Bessemer Billets	12 10 0	—
Hard Basic ,,	9 15 0	—
Soft ,,	7 10 0 to 9 0 0	
Hoops	12 5 0	—
Soft Wire Rods	11 0 0	—
MIDLANDS—		
Small Rolled Bars	9 15 0 to 10 0 0	
Bessemer Billets	7 10 0 to 8 0 0	
Hoops	12 0 0 to 12 10 0	
Gas Tube Strip	10 10 0	—
Sheets (24 W.G.)	13 10 0 to 14 0 0	
Galv. Sheets (f.o.b. L'pool)	16 0 0 to 16 10 0	
Angles	10 0 0	—
Joists	10 10 0	—
Tees	11 0 0	—
Bridge and Tank Plates	10 10 0	—

NON-FERROUS METALS.

SWANSEA—	
Tin-plates, I.C., 20 by 14	18/6 to 19/-
Block Tin (cash)	152 0 0
,, (three months)	153 15 0
Copper (cash)	61 0 0
,, (three months)	61 17 6
Spanish Lead (cash)	20 15 0
,, (three months)	20 12 6
Spelter (cash)	23 17 6
,, (three months)	24 12 6
MANCHESTER—	
Copper, Best Selected Ingots	65 10 0
,, Electrolytic	68 0 0
,, Strong Sheets	92 0 0
,, Loco Tubes	0 1 2
Brass Loco Tubes	0 1 0
,, Condenser	0 1 3
Lead, English	22 10 0
,, Foreign	21 0 0

(*Metal prices practically unchanged*).

FERRO ALLOYS.

(*All prices now nominal*).

	Per Ton.	Per Unit
Tungsten Metal Powder	1/8 per lb.	
Ferro Tungsten	1/5 per lb.	
Ferro Chrome, 4 p.c. to 6 p.c. carbon	£26	10/-
,, 6 p.c. to 8 p.c. ,,	£25 10 0	9/-
,, 8 p.c. to 10 p.c. ,,	£24 10 0	8/-
,, Specially Refined		
MAX. 2 p.c. carbon	£70	26 -
,, 1 p.c. ,,	£88	30/-
,, 0·75 p.c. carbon	£104	37/-
,, carbon free	2/- per lb.	
Metallic Chromium	5/3 per lb.	
Ferro Manganese (per ton)	£15 for home.	
,, Silicon, 45 p.c. to 50 p.c.	£13 0 0 scale 5/- per unit	
,, ,, 75 p.c.	£24 10 0 scale 6/- per unit	
,, Vanadium	20/- per lb.	
,, Molybdenum	7/- per lb.	
,, Titanium (carbon free)	1/3 per lb.	
Nickel (per ton)	£180	
Cobalt	14/- per lb.	
Aluminium (per ton)	£110 to £120 (British Official).	

FUELS.

SCOTLAND.

	Export.
LANARKSHIRE—	
(f.o.b. Glasgow)—Steam	22/-
,, ,, Ell	22/-
,, ,, Splint	23/6 to 26/-
,, ,, Trebles	25/-
,, ,, Doubles	22/9
,, ,, Singles	18/6
AYRSHIRE—	
(f.o.b. Ports)—Steam	22/-
,, ,, Splint	23/6
,, ,, Trebles	25/-
FIFESHIRE—	
(f.o.b. Methil or Burntisland)—Steam	19,6 to 23/-
Screened Navigation	28/-
Trebles	25/6
Doubles	22/-
Singles	18/6
LOTHIANS—	
(f.o.b. Leith)—Best Steam	22/6
Secondary Steam	22/-
Trebles	25/6
Doubles	23/-
Singles	18/6

ENGLAND.

(8) N.W. COAST—	
Steams	33/-
Household	40/- to 55/-
Coke	32/-
NORTHUMBERLAND—	
Best Steams	24/- to 26/-
Second Steams	22/- to 23/-
Steam Smalls	14/- to 15/-
Unscreened	21/6
Household	25/- to 30/-
DURHAM—	
Best Gas	21/6 to 22/-
Second	20/- to 21/-
Household	25/- to 30/-
Foundry Coke	32/- to 33/-

SHEFFIELD—	INLAND.
S. Yorks. Best Steam Hards	23/6 to 25/- —
Derbyshire Hards	23/- to 23,6 —
Seconds	22/- to 23/- —
Cobbles	22/- to 23/- —
Nuts	18/- to 19/- —
Washed Smalls	13/- to 15/- —
Best Hard Slacks	14/- to 15/- —
Seconds ,,	11/- to 12/- —
Soft Nutty ,,	10/- to 11/- —
Pea ,,	8/- to 9/- —
Small ,,	5/6 to 7/- —
House, Branch	37/- to 39/- —
,, Best Silkstone	34/- to 37/- —
Blast Furnace Coke (Inland and Export)	17/6 to 27/6

(9) SOUTH WALES.

CARDIFF—	
Steam Coals:	
Best Smokeless Large	25/-
Second ,, ,,	24/6 to 24/9
Best Dry Large	24/6 to 25/-
Ordinary Dry Large	23/6 to 24/-
Best Black Vein Large	24/- to 24/6
Western Valley ,,	23/- to 24/-
Best Eastern Valley Large	23/- to 24/-
Ordinary ,, ,,	22/- to 23/-
Best Steam Smalls	19/- to 20/-
Ordinary ,,	14/- to 18/-
Washed Nuts	27/6 to 32/6
No. 3 Rhondda Large	27/6 to 30/-
,, ,, Smalls	19/- to 20/-
No. 2 ,, Large	22/- to 23/-
,, ,, Through	19/- to 21/-
,, ,, Smalls	15/- to 16/-
Coke (export)	32/6 to 35/-
Patent Fuel	24/- to 27/-
Pitwood (ex ship)	30/- to 31/-
SWANSEA—	
Anthracite Coals:	
Best Large	40/- to 45/-
Seconds	35/- to 40/-
Red Vein	32/6 to 35/-
Big Vein	40/- to 45/-
Machine-made Cobbles	70/- to 72/6
Nuts	70/- to 72/6
Beans	50/- to 55/-
Peas	20/- to 22,6
Breaker Duff	7/6 to 8/-
Rubbly Culm	12 - to 12 6
Steam Coals:	
Large	22 6 to 25/-
Seconds	20/- to 22,6
Smalls	12/6 to 15/-
Cargo Through	18,6 to 20/-

(1) Delivered. (2) Net Makers' works. (3) At furnaces. (4) Delivered Sheffield. (5) Glasgow, Lanarkshire and Ayrshire.

(6) Home Prices—All delivered Glasgow Station. Boiler Plates 10/- extra delivered England. (7) Export Prices—F.O.B. Glasgow.

(8) Except where otherwise indicated coals are per ton at pit for inland and f.o.b. for export and coke is per ton on rail at ovens and f.o.b. for export. (9) Per ton f.o.b.

French Engineering Notes.

(From our Correspondent in Paris.)

Franco-British Trade.

THIS country is the nearest market to Britain and it offers the best guarantee to sellers, for despite the financial embarrassments at the moment, the situation of buyers is relatively better than it is in other countries with depreciated money values, and as there is a growing need for all classes of goods, it is certain that business could be done if only facilities were offered for more active commercial relations on both sides of the Channel. During the past three years the imports from Britain have been rapidly declining, as the result mainly of the exchange rate, aggravated by the higher import duties, which put up prices against French buyers to such an extent as to convince them of the impossibility of purchasing British goods at all. The difficulty was increased by the reluctance of many British firms to stabilise prices by consenting to sell at a fixed rate of exchange. The imports of machinery to France have therefore fallen to a level that means a temporary loss, at any rate, of this market to British manufacturers. If we are to wait for a return to normal conditions of exchange, it is probable that a recovery will be delayed for a considerable time, and it is therefore desirable to see what can be done to improve the situation under existing circumstances. Unless the old commercial relations between the two countries are re-established soon, the difficulties in the way of recovering business will increase. Traders in France who have anything to do with Germany are unanimous in declaring that a continuance of the present state of things can only benefit that country. In most branches of engineering the productive costs are declared to be one-half of what they are in France, so that the German manufacturer can afford to take upon himself the heavy protective duties imposed against him and yet undersell in this market. It is therefore time that something should be done in the way of reciprocity to provide facilities to British firms for doing business in France, at the same time that French producers will be enabled to sell their products in Britain. It is true that the conditions are not favourable to any such arrangement at the moment. The past week or two has witnessed an unexpected slump at a time when evidences had been pointing to a revival of confidence. The political troubles have been creating a feeling of distrust in the immediate future, which is observable in the exceptional stringency of the money market. There is no capital available for any kind of industrial or commercial undertaking, and no improvement is anticipated until the air is cleared of the doubts and misgivings which cloud the forthcoming Genoa Conference. Advantage has been taken of this reserved attitude by certain people to work up a financial scare, with the result that some of the banking institutions have been brought under undeserved suspicion, and so long as such manœuvres continue to sap confidence there is no hope of doing much business in this country, whatever may be the fiscal or other facilities offered.

Commercial Arrangements.

The financial difficulties, in so far as they affect trade, are less serious than they are made to appear. The country is in need of a great deal of machinery and manufactured goods, and buyers are quite capable of paying for them. If the negotiations concerning the Genoa Conference can be settled satisfactorily, and no other disturbing influence arises, the situation will be eminently favourable to a revival of trade, when capital will once more find its way into industrial ventures and the various engineering enterprises, which are at present held up through want of money, will be put in hand. The feeling is general that the commercial crisis is due to political and financial troubles which are both of a temporary character, and that as soon as they are adjusted the outlook will be more reassuring than it has been at any time during the past three years. If British firms are to participate in the expected recovery, it can only be as a direct result of the political negotiations. The fiscal policy of France aims at the creation of a series of independent commercial arrangements with different countries in place of the old treaties of commerce, such arrangements being established on a purely reciprocal basis, whereby French products will receive specially favoured treatment in return for the provision of facilities for the importation of certain foreign goods. To permit of that policy being carried into effect, the import duties were raised to a level far above what would appear to be justified by the depreciation of money values. The immediate result was to provoke retaliation, when most countries hedged themselves in with tariffs which are having a disastrous effect upon foreign trade. The hopes that were entertained of other countries willingly coming to terms with France have not been fulfilled. It is true that an arrangement has just been signed with Poland, and that satisfactory negotiations are in progress with Czecko-Slovakia, but other nations have so far shown an uncompromising resistance, to the extent that all commercial relations with Spain have been practically suspended and negotiations are being continued laboriously with Italy, so far with little prospect of success. It is doubtful whether the French policy will constitute a satisfactory basis of agreement with Britain, for most of the manufactured goods capable of being imported are now being made in this country, and any concessions in favour of the British industry would certainly be met with resistance from home firms, many of which are still clamouring for further protection. Still, it is clear that if the essentially French products and goods are to find markets abroad, the home engineering and other industries must submit to the competition of imported manufactures, otherwise there can be no reciprocity. The extent of that reciprocity will depend largely upon political negotiations, which are becoming more and more inseparable from commercial arrangements, and if the two countries could settle upon some common political policy the commercial facilities would follow as a matter of course.

British Patent Specifications.

When an invention is communicated from abroad the name and address of the communicator are printed in italics.

When an abridgment is not illustrated the Specification is without drawings.

Copies of Specifications may be obtained at the Patent Office Sale Branch, 25, Southampton-buildings, Chancery-lane, W.C., at 1s. each.

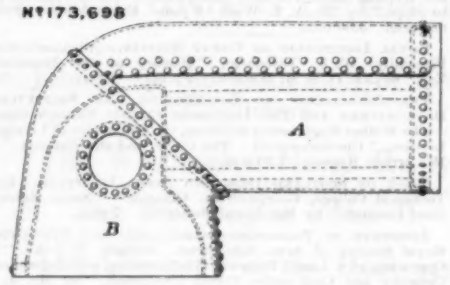
The date first given is the date of application; the second date, at the end of the abridgment, is the date of the acceptance of the complete Specification.

STEAM GENERATORS.

173,698. January 18th, 1921.—IMPROVEMENTS IN OR RELATING TO BOILERS OF THE LOCOMOTIVE OVAL BOX TYPE, Mann's Patent Steam Cart and Wagon Company, Limited, and James Hutchinson Mann, both of Pepper-road, Hunslet, Leeds.

THE boiler shell A comprises a plate bent or rolled in the form of a cylinder, which constitutes the barrel, and a second plate bent or rolled into a truncated cone and constituting the external

Nº 173,698



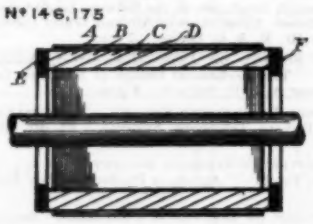
fire-box B. The arrangement of the joints is clearly shown. The front end of the barrel is closed by a tube plate in the usual way. —*January 12th*, 1922.

DYNAMOS AND MOTORS.

146,175. June 25th, 1920.—IMPROVEMENTS IN AND RELATING TO ASYNCHRONOUS MOTORS, Siemens Schuckertwerke, G.M.B.H., of Siemensstadt, near Berlin.

Twisted subdivided conductors, such as A B C D, are placed in the individual slots and are connected together by end rings E F. The twisted conductors may be constructed either by winding the subdivided conductors round a flat core or preferably by first winding the conductors as a circular tube and then pressing them flat. The conductors are insulated from each other, and the amount of insulation used depends on the voltage

Nº 146,175



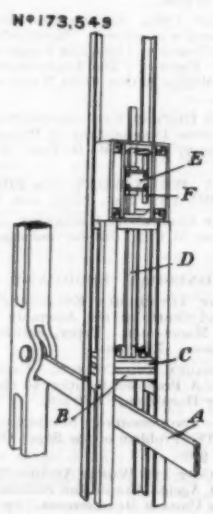
that is likely to occur between the conductors. Layers of iron may be used for increasing the crowding of the current in the slots. The object of using these subdivided twisted conductors is to increase the resistance while the motor is running with a large slip, as when it is starting, whilst the current is uniformly distributed in the conductors near the zero rotor frequency. As the frequency increases the density of the current in the part of the conductor lying near the opening of the slot becomes greater than at the bottom of the slot.—*December 28th*, 1921.

SWITCHGEAR.

173,549. July 20th, 1920.—IMPROVEMENTS IN AN AUTOMATIC SWITCH WHICH IS PARTICULARLY SUITABLE FOR ELECTRIC HOISTS, Albert Satterthwaite, of 5, Leander-road, Wallasey, Cheshire.

The hoisting drum, which is not shown in the drawing, is driven by an electric motor, and is controlled while lowering by a brake

Nº 173,549



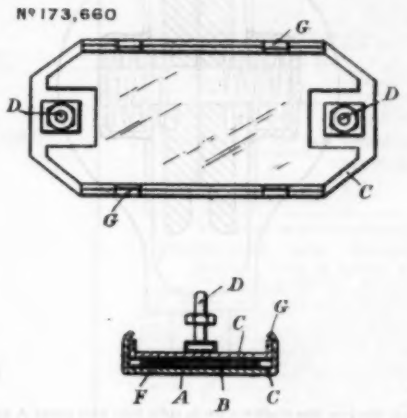
arm A in the well-known usual manner. When lifted by means of a rope, this arm comes into contact with a plate B, connected by springs with a plate C moving in guides and connected to a spindle D. The plate B has considerable weight and therefore assists in the returning of the plate C and switch spindle D to the lower position when the brake arm A has moved out of contact with it. The springs provide a smooth and even engagement of the parts. The spindle has at its upper end an insulated block E carrying a carbon brush adapted to move over a contact surface F, to complete or break, as desired, the circuit of an automatic or similar starter for the electric motor —*December 20th*, 1921.

LIGHTING AND HEATING.

173,660. November 4th, 1920.—IMPROVEMENTS IN ELECTRICAL HEATING UNITS, Harry Cheshire, of Crammer and Cheshire, of Stewart-street, Spring-hill, Birmingham, and Vincent Summerhayes, of the same address.

Each heating unit consists of a member A of insulating material around which is wound a coil of high-resistance wire or ribbon B. The member A is secured between two insulating plates C of mica or other suitable material. The ends of the coil B are provided with terminals D which pass through the

Nº 173,660



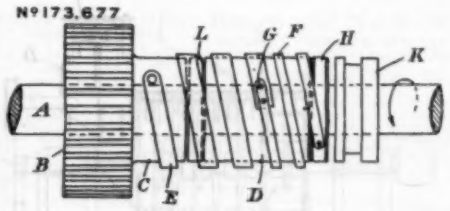
insulating plates C. Upon the outer side of each plate C is a metal clamping plate F. Each metal clamping plate is of channel section having turned up edges, and one of the plates F is provided with lugs G at its edges which are used for clamping the heating unit between the plates. The two plates F are therefore pressed towards each other so as to grip the heating unit between them, and while this pressure is being exerted the lugs G upon the lower plate are bent over the edges of the other plate.—*January 12th*, 1922.

TRANSMISSION OF POWER.

173,677. November 25th, 1920.—IMPROVEMENTS IN CLUTCHES, William Sumner, of 3, St. Michael's Church-road, and Joseph Torrey, of Hardwick, Park-drive, Blundellsands, Liverpool.

The driving shaft A has a pinion B mounted loosely upon it, and the pinion has an extended boss C. On the driving shaft there is also a collar D. A stout band coil E and a lighter coil F are wound round the parts, as shown, the light coil being attached to the heavy coil at G, whilst the right end of the light

Nº 173,677



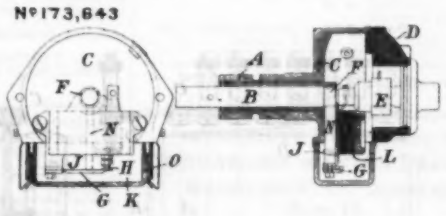
coil is attached to a loose ring H which is made of leather or has leather-faced sides. K is a loose grooved collar, and L a loose plain ring. To put the clutch into operation the sliding sleeve or collar K is moved towards the fixed collar D by means of a forked lever so that the friction ring H is taken round in the direction of the arrow.—*January 12th*, 1922.

MOTOR CARS AND ROAD TRAFFIC.

173,643. October 21st, 1920.—IMPROVEMENTS RELATING TO DISTRIBUTORS FOR HIGH-TENSION IGNITION APPARATUS, Ernest Anstey Watson, M.Sc., and the M.L. Magneto Syndicate, Limited, of Victoria Works, West Orchard, Coventry.

A cylindrical metal body A carrying a rotatable spindle B is formed with a chamber C which is closed at its front end by a cover D of insulating material and contains the high-tension terminals and connections. On the end of the spindle within

Nº 173,643



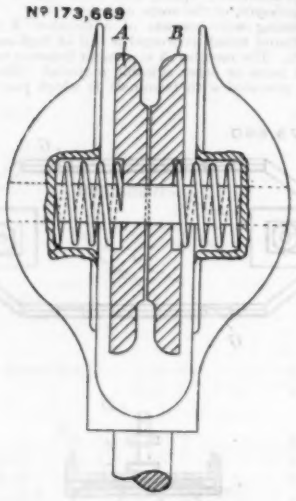
the cover there is the usual distributor arm E which coacts with the terminals. The spindle is also provided with the interrupter cam F. The interrupter consists of a spring arm G provided with a contact H which co-operates with a fixed contact, both being mounted on a metal plate J in a lateral cavity K, so that the spring arm and contacts lie wholly outside the body. On the plate J is also mounted the condenser L, which is partially enclosed by a metal cover. The interrupter and condenser are arranged to form a single unit which can easily be attached as a whole to the distributor or removed therefrom as required. Motion is trans-

mitted to the spring blade of the interrupter from the cam by a thrust rod N, preferably of insulating material, the rod being arranged to slide in a groove. The interrupter is enclosed by a separate detachable cover O.—*January 12th*, 1922.

TRAMWAYS AND RAILWAYS.

173,669. November 12th, 1920.—IMPROVEMENTS IN TROLLEY HEADS FOR ELECTRICALLY PROPELLED VEHICLES, Robert John Danson, of 11A, South Bank-road, Edge-lane, Liverpool.

The accompanying drawing shows a trolley head constructed in accordance with this invention. It will be seen that the part

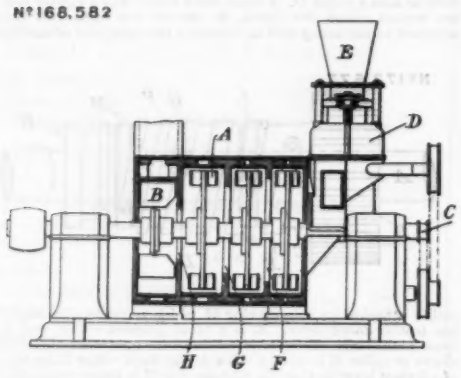


which receives the trolley wire is split into two parts A and B, and the parts are pressed or held together by springs.—*January 12th*, 1922.

MISCELLANEOUS.

168,582. April 15th, 1921.—IMPROVEMENTS IN APPARATUS FOR PULVERISING COAL AND OTHER SUBSTANCES, The Powdered Fuel Plant Company, Limited, of 47, Queen Victoria-street.

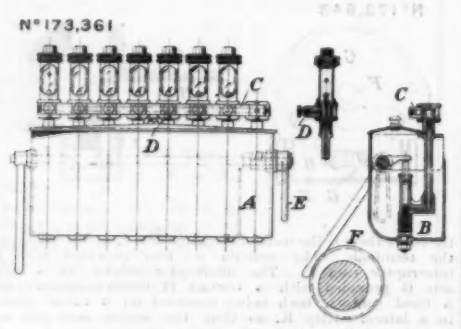
A pulveriser constructed in accordance with this invention is illustrated. The main shaft carries a plurality of discs, on each of which is mounted a plurality of impactors A. The shaft also carries the rotor B of a centrifugal fan. The discs with the impactors A and fan rotor rotate within a closed cylindrical divided casing. The line of division of the casing is in the horizontal plane and the two parts of the casing are hinged together. The shaft is driven by a prime mover through belting running on the pulley to be seen on the left. Mounted on the right-hand end of the shaft is a second pulley C, which, by means of other pulleys and belting, drives the shaft of



a distributor D interposed between the lower end of a feed hopper E and an inlet to the casing. The distributor controls the supply of raw or untreated coal to the pulveriser. It will be seen that the casing is divided into a plurality of compartments, and there are openings at F G H. The chambers in which the discs work increase in size from the inlet to the fan B and the areas of the openings in the partitions decrease in the same direction.—*January 5th*, 1922.

173,361. October 15th, 1920.—SIGHT-FEED LUBRICATORS, W. Scholes and H. R. Hall, Victoria Works, Denton, Manchester.

In order to replenish the supply of water in the sight-feed glasses of lubricators, the inventors provide a reservoir A of water in the end of the oil box. A pump B is used to force the



water into a duct C, which communicates with each of the glasses. There is a screw-down valve D at each of the connections. The pump is operated either by the handle E or the lever and cam F.—*January 5th*, 1922.

Forthcoming Engagements.

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of its insertion, the necessary information should reach this office on, or before, the morning of the Wednesday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

TO-DAY.

OLD CENTRALIANS.—Engineers' Club, 39, Coventry-street, W. 1. Annual dinner. 7 p.m.

JUNIOR INSTITUTION OF ENGINEERS.—Caxton Hall, S.W. "Water Purification for Boiler Feed Purposes," by Mr. W. J. Leaton. 8 p.m.

INSTITUTE OF METALS: SHEFFIELD LOCAL SECTION.—Mappin Hall, The University, St. George's-square, Sheffield. "The Mechanical Properties of Metals," by Mr. F. C. A. H. Lantsberry. 7.30 p.m.

THE INSTITUTION OF MECHANICAL ENGINEERS.—Storey's Gate, St. James's Park, S.W. Annual general meeting. "Electric Welding Applied to Steel Construction, with special reference to Ships," by Mr. A. T. Wall. 6 p.m. Extraordinary general meeting. 5.50 p.m.

ROYAL INSTITUTION OF GREAT BRITAIN.—Albemarle-street, Piccadilly, W. 1. Discourse, "History of the Mammalian Ear," by Mr. D. S. M. Watson. 9 p.m.

THE ASSOCIATION OF ENGINEERING AND SHIPBUILDING DRAUGHTSMEN AND THE LIVERPOOL CREDIT REFORM GROUP.—The Walker Engineering Building, the University of Liverpool. Lecture, "Unemployment: The Cause and the Remedy," by Mr. Arthur Kitson. 7.30 p.m.

WEST OF SCOTLAND IRON AND STEEL INSTITUTE.—Royal Technical College, George-street, Glasgow. "Some Notes on Steel Castings," by Mr. Joseph Jefferson. 7 p.m.

INSTITUTE OF TRANSPORT: GRADUATES AND STUDENTS.—Royal Society of Arts, John-street, Adelphi, W.C. 2. "The Operation of a Large Tramway Undertaking, with reference to Capacity and Cost under Given Conditions," by Mr. J. M. McElroy. 5 p.m.

SATURDAY, FEBRUARY 18TH.

INSTITUTION OF AUTOMOBILE ENGINEERS.—Annual dinner of the London Graduates at the Boulogne Restaurant, 27, Gerrard-street, W., at 7.30 p.m.

ASSOCIATION OF ENGINEERING AND SHIPBUILDING DRAUGHTSMEN: MERSEYSIDE BRANCH.—University Engineering Building, Liverpool. "Psycho-therapeutics, with reference to Psycho-analysis," by Mr. D. A. Betts Taplin. 7.30 p.m.

MONDAY, FEBRUARY 20TH.

INSTITUTION OF AUTOMOBILE ENGINEERS.—Meeting of the Scottish Centre at the Royal Technical College, Glasgow. Paper, "The Physical Properties of Motor Fuels: A Discussion of their Bearing on the Motor Industry," by Dr. W. R. Ormandy and Mr. E. C. Craven. 7.30 p.m.

INSTITUTION OF AUTOMOBILE ENGINEERS.—Meeting of the Loughborough Graduates at the College, Loughborough. Paper, "The Relative Advantages of Air and Water Cooling for Small Cars," by Mr. E. A. C. Oliver. 7 p.m.

ROYAL SOCIETY OF ARTS.—John-street, Adelphi. Cantor Lecture. "The Mechanical Design of Scientific Instruments," by Professor A. F. C. Pollard. 8 p.m.

BRADFORD ENGINEERING SOCIETY.—Technical College, Bradford. "Private Telephone Systems," by Mr. R. D. Spurr. 7.30 p.m.

THE PETTER ENGINEERING SOCIETY.—Petter's Institute, 28, Kingston, Yeovil. "Agents of Production," by Mr. J. W. Ross. 8 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS.—Savoy-place, Victoria Embankment, W.C. 2. Informal meeting. "On the Emergency Use of Oil Fuel during the Recent Coal Strike," by Mr. E. F. Hetherington. 7 p.m.

EAST INDIA ASSOCIATION.—Caxton Hall, Westminster. "Hydro-electric Power in India," by Mr. A. T. Arnall. 3.30 p.m.

TUESDAY, FEBRUARY 21ST.

INSTITUTION OF ELECTRICAL ENGINEERS.—Hotel Cecil, Strand. Annual dinner. 7 for 7.30 p.m.

INSTITUTION OF AUTOMOBILE ENGINEERS.—Ordinary general meeting of the Institution at the Chamber of Commerce, New-street, Birmingham. Paper, "The Physical Properties of Motor Fuels: A Discussion of their Bearing on the Motor Industry," by Dr. W. R. Ormandy and Mr. E. C. Craven. 7 p.m.

WOMEN'S ENGINEERING SOCIETY.—Club Room, 26, George-street, Hanover-square, W. "Model Experiments in Aeronautics," by Mrs. H. Irving. 6.15 p.m.

INSTITUTE OF MARINE ENGINEERS.—The Minories, Tower Hill. E. 1. "Types of Large Marine Engines," by Mr. D. R. Hutchinson. 6.30 p.m.

INSTITUTION OF CIVIL ENGINEERS.—Great George-street, S.W. 1. To be further discussed: "Hydro-electric Installations of the Barcelona Traction, Light and Power Company," by Dr. H. F. Parshall. Paper: "The Improvement of the Port of Valparaiso," by Messrs. Arthur Cliffe Walsh and William Frank Stanton. 6 p.m.

GRANTHAM AND DISTRICT ENGINEERING SOCIETY.—Co-operative Hall. "Modern Development of Power Transmission by Electrical Machinery," by Mr. W. H. Tew. 7.45 p.m.

TUESDAY, WEDNESDAY AND THURSDAY, FEBRUARY 21ST, 22ND, AND 23RD.

INSTITUTION OF ELECTRICAL ENGINEERS.—Savoy-place, Victoria Embankment, W.C. 2. Jubilee meetings. For programme see page 133.

WEDNESDAY, FEBRUARY 22ND.

INSTITUTION OF AUTOMOBILE ENGINEERS.—Meeting of the North of England Centre at the Assembly Room, Education Offices, Salford, Manchester. Paper, entitled "Gearing," by Mr. W. H. Saunders. 7.30 p.m.

INDUSTRIAL LEAGUE AND COUNCIL.—Caxton Hall, Caxton-street, S.W. 1. "A Proposed Solution to the Transport Problem," by Mr. Roy Horniman. 7.30 p.m.

THORNYCROFT ENGINEERING SOCIETY.—Works Canteen, Basingstoke. "The Problem of the Small Oil Engine," by Mr. W. P. Sillince. 7 p.m.

INSTITUTE OF COST AND WORKS ACCOUNTANTS.—Institute of Chartered Patent Agents, Staple Inn Buildings, Holborn, W.C. Lecture: "Some Units of Measurement," by Mr. J. C. Todman. 7 p.m.

NORTHAMPTON ENGINEERING COLLEGE ENGINEERING SOCIETY.—St. John-street, Clerkenwell, E.C. 1. Paper: "Commercial Testing of Direct-current Motors and Generators," by Mr. A. T. Davis. 5.30 p.m.

THURSDAY, FEBRUARY 23RD.

ENGINEERING GOLFING SOCIETY.—The Institution of Civil Engineers, Great George-street, Westminster. Annual general meeting. 12 noon.

INSTITUTION OF AUTOMOBILE ENGINEERS.—Ordinary general meeting of the Institution at the Masonic Hall, Little Park-street, Coventry. Paper, "Engine Lubrication," by Mr. E. L. Bass. 7.45 p.m.

INSTITUTION OF AUTOMOBILE ENGINEERS.—Meeting of the Wolverhampton Centre at the Victoria Hotel, Wolverhampton. Paper, "Some Faults Commonly Found in Suspension," by Mr. G. H. Lanchester. 7.30 p.m.

INSTITUTION OF LOCOMOTIVE ENGINEERS.—The Engineers' Club, Coventry-street, Leicester-square. Annual dinner. 6.30 p.m.

FRIDAY, FEBRUARY 24TH.

JUNIOR INSTITUTION OF ENGINEERS.—Caxton Hall, S.W. Lecture, "Curved Beams, Rings and Chain Links," by Mr. E. G. Coker. 8 p.m.

THE ASSOCIATION OF ENGINEERING AND SHIPBUILDING DRAUGHTSMEN: MERSEYSIDE BRANCH.—The Walker Engineering Building, The University, Liverpool. Lecture, "The Printing Telegraph," by Mr. H. H. Harrison. 7.30 p.m.

WEST BROMWICH ENGINEERING SOCIETY.—Technical School. "Ball and Roller Bearings," by Mr. W. A. Ecob. (Lantern.) 7.30 p.m.

INSTITUTION OF PRODUCTION ENGINEERS.—Institution of Mechanical Engineers, Storey's-gate, S.W. "Intensive Production of Automobile Bodies," by Mr. G. W. Eastwood. 7.30 p.m.

ROYAL INSTITUTION OF GREAT BRITAIN.—Albemarle-street, Piccadilly, W. 1. Discourse on "The Age of the Earth," by Dr. John Jolly. 9 p.m.

ROYAL METAL TRADES' PENSION SOCIETY.—Grand Hall, Hotel Cecil. Annual ball.

MANCHESTER ASSOCIATION OF ENGINEERS.—Memorial Hall, Albert-square, Manchester. Paper, "Recent Developments in the Treatment of Manchester Sewage," by Dr. E. Ardern. 7 p.m.

INSTITUTION OF MECHANICAL ENGINEERS: GRADUATES' ASSOCIATION.—Connaught Rooms, Great Queen-street, Kingsway. Annual dinner. 6.45 for 7.15 p.m.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.—Lecture Theatre of the Literary and Philosophical Society, Newcastle-upon-Tyne. "Some Problems of Marine Diesel Engine Design," by Mr. P. Belyavin. 7.30 p.m.

SATURDAY, FEBRUARY 25TH.

JUNIOR INSTITUTION OF ENGINEERS: NORTH-EASTERN SECTION.—Electrical Engineering Lecture Theatre, Armstrong College, Newcastle-on-Tyne. "Drop Stamping and General Forge Work," by Messrs. E. F. Lough and R. N. Richardson. 7 p.m.

MONDAY, FEBRUARY 27TH.

INSTITUTION OF MECHANICAL ENGINEERS: GRADUATES' ASSOCIATION.—Storey's Gate, St. James's Park, S.W. Special lecture. "Metallurgy in relation to Mechanical Engineering," by Sir Henry Fowler, K.B.E. 7 p.m.

ROYAL SOCIETY OF ARTS.—John-street, Adelphi, W.C. 2. Cantor Lecture II.. "The Mechanical Design of Scientific Instruments," by Professor A. F. C. Pollard. 8 p.m.

TUESDAY, FEBRUARY 28TH.

INSTITUTION OF AUTOMOBILE ENGINEERS.—Meeting of the Coventry Graduates at the Broadgate Café, Broadgate. Paper, "The Fuel Question," by Mr. J. Newey. 7.45 p.m.

INSTITUTION OF AUTOMOBILE ENGINEERS.—Visit of the London Graduates to the coachbuilding works of Messrs. Barker and Co., Limited, Olaf-street, Latimer-road, Notting Hill, W. 11. Meet outside the works at 2.30 p.m.

INSTITUTION OF AUTOMOBILE ENGINEERS.—Informal meeting at the Institution of Mechanical Engineers, Storey's Gate, St. James's Park, S.W. 1, when various recording instruments used on motor cars will be demonstrated and discussed. 7.30 p.m.

KEIGHLEY ASSOCIATION OF ENGINEERS.—Through the courtesy of the City Electrical Engineer and Manager, a visit has been arranged to the Valley-road works of the Bradford Corporation electricity department. Train leaves Keighley 5.57 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS: SCOTTISH CENTRE.—Grosvenor Restaurant, Glasgow. Dinner.

WEDNESDAY, MARCH 1ST.

THE NEWCOMEN SOCIETY.—Caxton Hall, S.W. "Timothy Hackworth and the Locomotive," by Mr. Robert Young. 5 p.m.

FRIDAY, MARCH 3RD.

BRITISH NON-FERROUS METALS RESEARCH ASSOCIATION.—Queen's Hotel, Birmingham. Annual meeting. 12.50 p.m.

JUNIOR INSTITUTION OF ENGINEERS.—Caxton Hall, S.W. Lecturette, "Factory Administration," by Mr. E. T. Elbourne. 8 p.m.

INSTITUTION OF MECHANICAL ENGINEERS.—Storey's-gate, S.W. 1. Informal meeting. "Spiral Bevel *v.* Straight-tooth Bevel," by Mr. A. P. Bale. 7 p.m.

SATURDAY, MARCH 4th.

INSTITUTION OF LOCOMOTIVE ENGINEERS.—Caxton Hall, S.W. 1. "Lubrication of the Modern Locomotive," by Mr. J. Clayton. 2.15 p.m.

WEDNESDAY AND THURSDAY, MARCH 8TH AND 9TH.

INSTITUTE OF METALS.—Institution of Mechanical Engineers, Storey's-gate, Westminster, S.W. 1. Annual general meeting. 10 a.m. Annual dinner, March 8th, at Trocadero Restaurant, Piccadilly-circus, W. 1. 8 p.m.

THURSDAY, MARCH 9TH.

FARADAY SOCIETY AND THE OIL AND COLOUR CHEMISTS' ASSOCIATION.—Joint meeting at Chemical Society, Burlington House, W. 1. Papers on "The Properties of Powders," by Messrs. L. C. McHatton, C. A. Klein, W. J. Palmer, and R. W. Whymper; Dr. J. W. French and R. S. Morrell; Professor T. Martin Lowry and P. G. S. Boswell. 8 p.m.

WEDNESDAY, MAY 3RD.

INSTITUTE OF METALS.—Institution of Mechanical Engineers, Storey's-gate, Westminster, S.W. 1. Annual May lecture: "The Relation of the Elements," by Sir Ernest Rutherford. 8 p.m.

THURSDAY AND FRIDAY, MAY 4TH AND 5TH.

IRON AND STEEL INSTITUTE.—Institution of Civil Engineers, Great George-street, S.W. 1. Annual meeting. Annual dinner, Thursday, May 4th, at Connaught Rooms, Great Queen-street, W.C.